

MUNI
MED

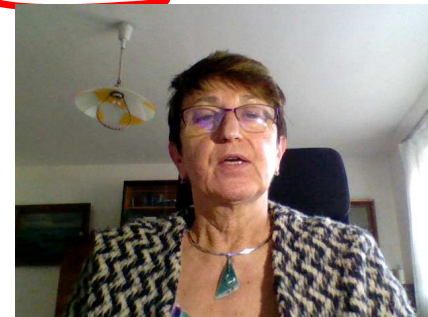
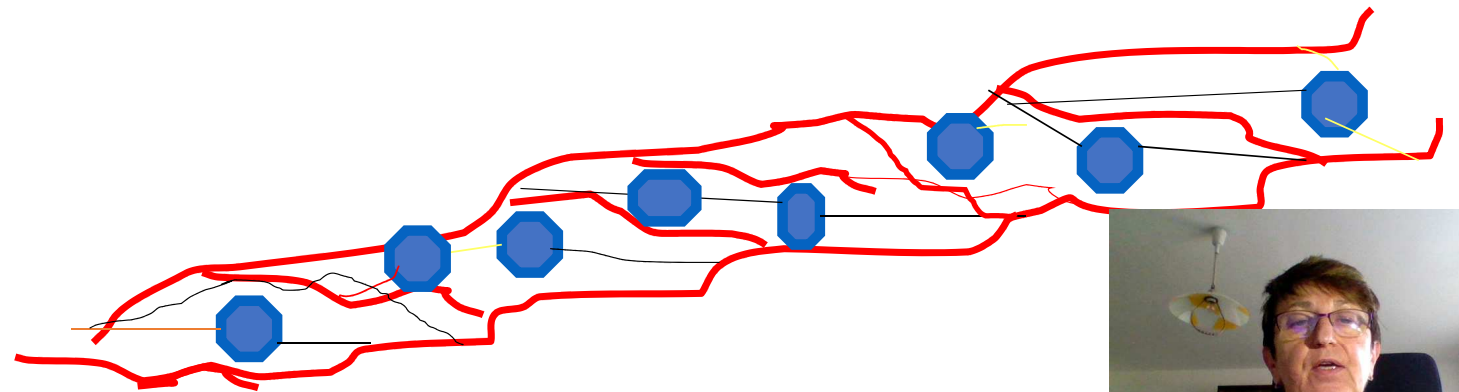
Restorative dentistry 3rd year Lecture 2

L. Roubalíková



Composite materials

Chemically bonded mixture of organic matrix and inorganic fillers



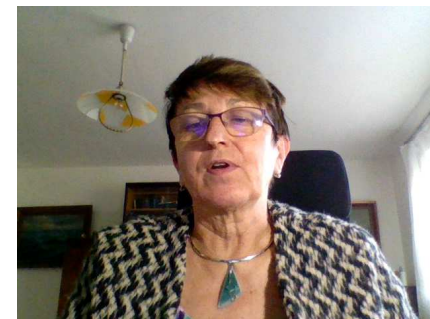
Coupling agent – binds organic matrix and the filler together



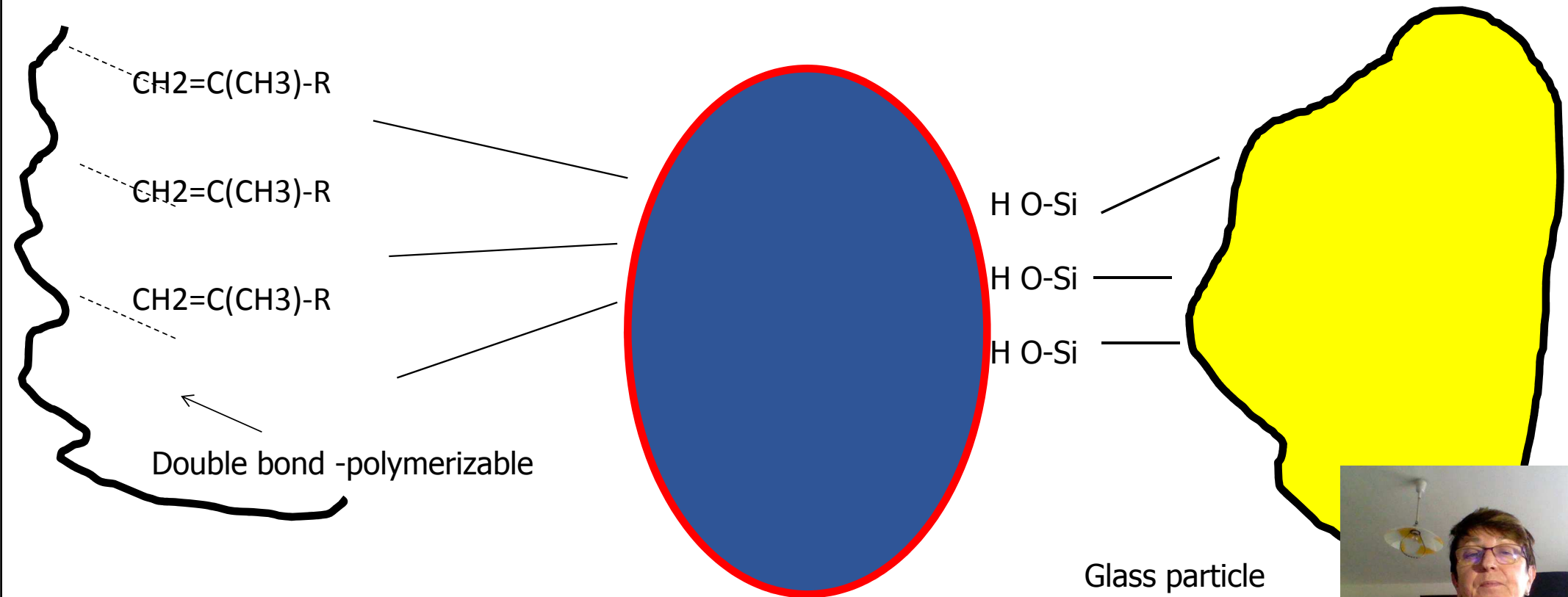
Homogenous distribution of the filler particles in the material



Excellent mechanical properties

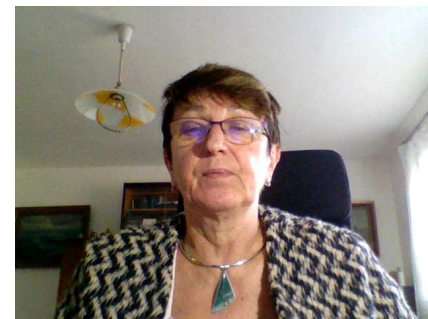


Binding of the coupling agents to glass particles



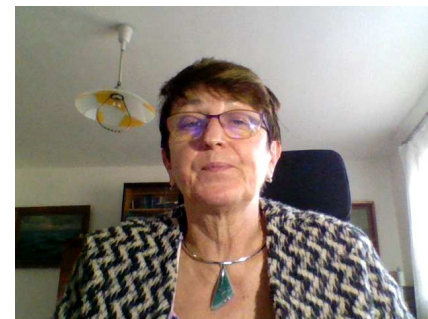
Importance of the components

- matrix – a transfer mechanical loading on inorganic fillers, protects the filler against moisture
- filler - a support of the material, carries the loading
- coupling agents - a homogenous distribution of the filler in matrix



Filler – material

- Milled quartz
- Aluminium silicate glass
- Silicon dioxide
- Prepolymer (composite material is polymerized with high pressure in fabrics, then milled – particles of the filler are made of cured composite)
- Complexes of microfiller (agglomerates) – e-g-. silicon dioxide or zirconium oxide



Filler acc to the size of particles

- Macrofiller (size of particles μm ot tenth of μm)
- Mikropnivo (hundredths od μm)
- Nanofiller (nm)
- Combination– hybrid
 - Conventional (μm)
 - Microhybrid (hundredths od μm , μm)
 - Nanohybrid (hundredths od μm , μm , nm)



Macrofiller

- Particles μm or tenths of μm
- Good mechanical resistance , abrasion resistance, bad polishability.

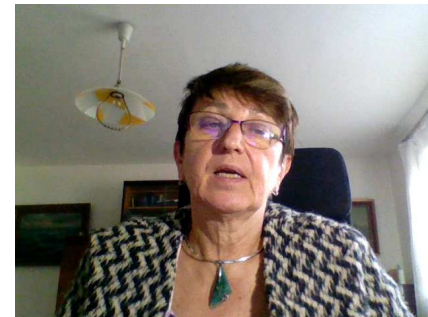


Microfiller

- Silicium dioxide (pyrogenous)
- Particles hundreths μm

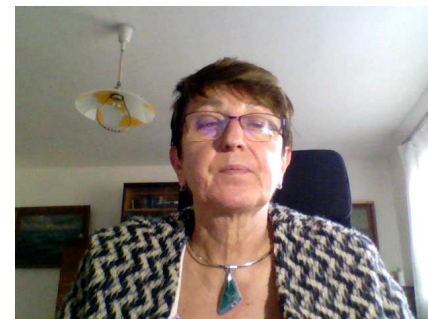
Less amount of filler due to big surface

Lower mechanical resistence, good polishability.



Microfiller in complex particles

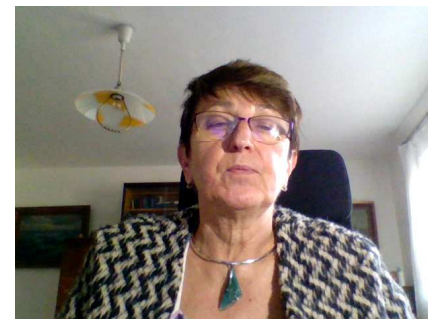
- Prepolymer
 - Agglomerates
- Higher amount of filler, good mechanical resistance, good polishability



Nanoparticles

- Particles 10 nm and less

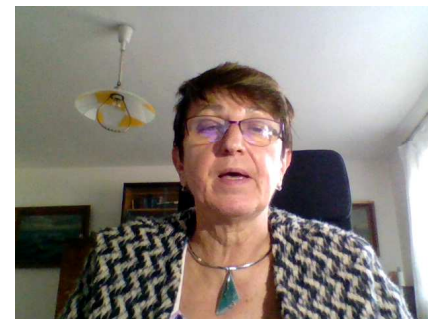
Special technology, size, shape and binding to monomer



Today

- Microhybrid or nanohybrid composites:

Good mechanical properties, good polishability, propagation of cracks is minimized.



Matrix

Bis GMA – Bowen's monomer • (2,2-bis[4-(2hydroxy-3-metakryloyloxypropoxy) • phenyl]propan)

- Bis DMA
- UDMA
- TEGMA /triethylenglykoldimethacrylate
- EGMA ethylenglykoldimethacrylate
- e Bis –GMA
- HDMA hexandioldimethacrylate

Dimethacrylates - mixture of materials with high and lower molecular weight



Matrix - modification

- Acid modified resins (compomers)
- Polysiloxan chains with polymerizable groups (ormocers)
- Silorans (ring opening monomers)



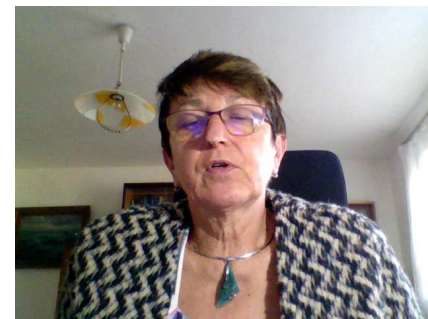
Coupling agent

- G -methacryloxypropyltrimetoxysilan (A 174)



Other components

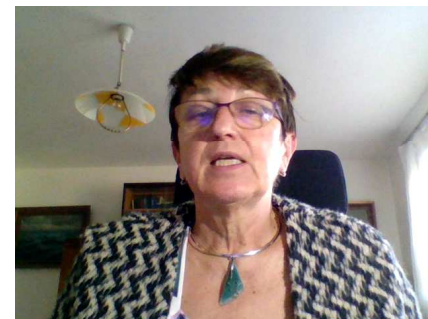
- Activator and initiator
- Pigments
- Fluorescents
- Absorbers of light
- Inhibitors



Selfcuring composites

- Tertiary amine Dibenzolyperoxide

• **Activator**  Initiator



Light curing composites

- Initiator and sometimes also activator
 - Camphorquinon CQ
 - Phenylpropandion PPP
 - Trimethylbenzoylphosphino xid TPO



Camphorquinon (CQ) - initiator

- Yellow colour
- Activator is present: etyl-4-(N,N'-dimetylamino)benzoát (4EDMAB), N,N'-dimetylaminoethylmetakrylat (DMAEMA)
- Light shades of composites: combination of CQ and other initiators.



Composite materials – basic characteristics

Matrix

Filler

Compressive strength



Elasticity



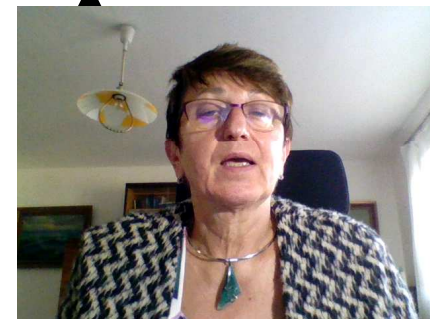
Polymerization shrinkage



Polymerization stress



Water sorption



Classification of composite filling materials

- Size of the filler particles

Macrofilled, microfilled (homogenous, non homogenous, hybrid)

- Matrix (monomers)

Dimethacrylate, acid modifies, ormocers, silorans

- Viskosity (flowable, thick)

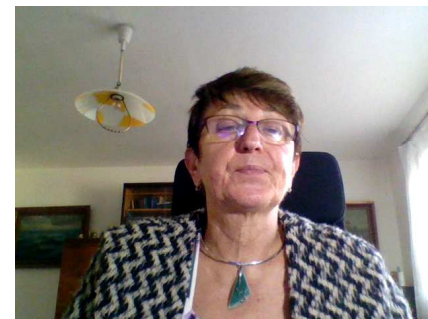


History

Dimetacrylates

Bowen 1960 – Bowen's monomer

Buoconore 1955 – acid etching



History

- Fusayama 1979
Adhesion to dentin

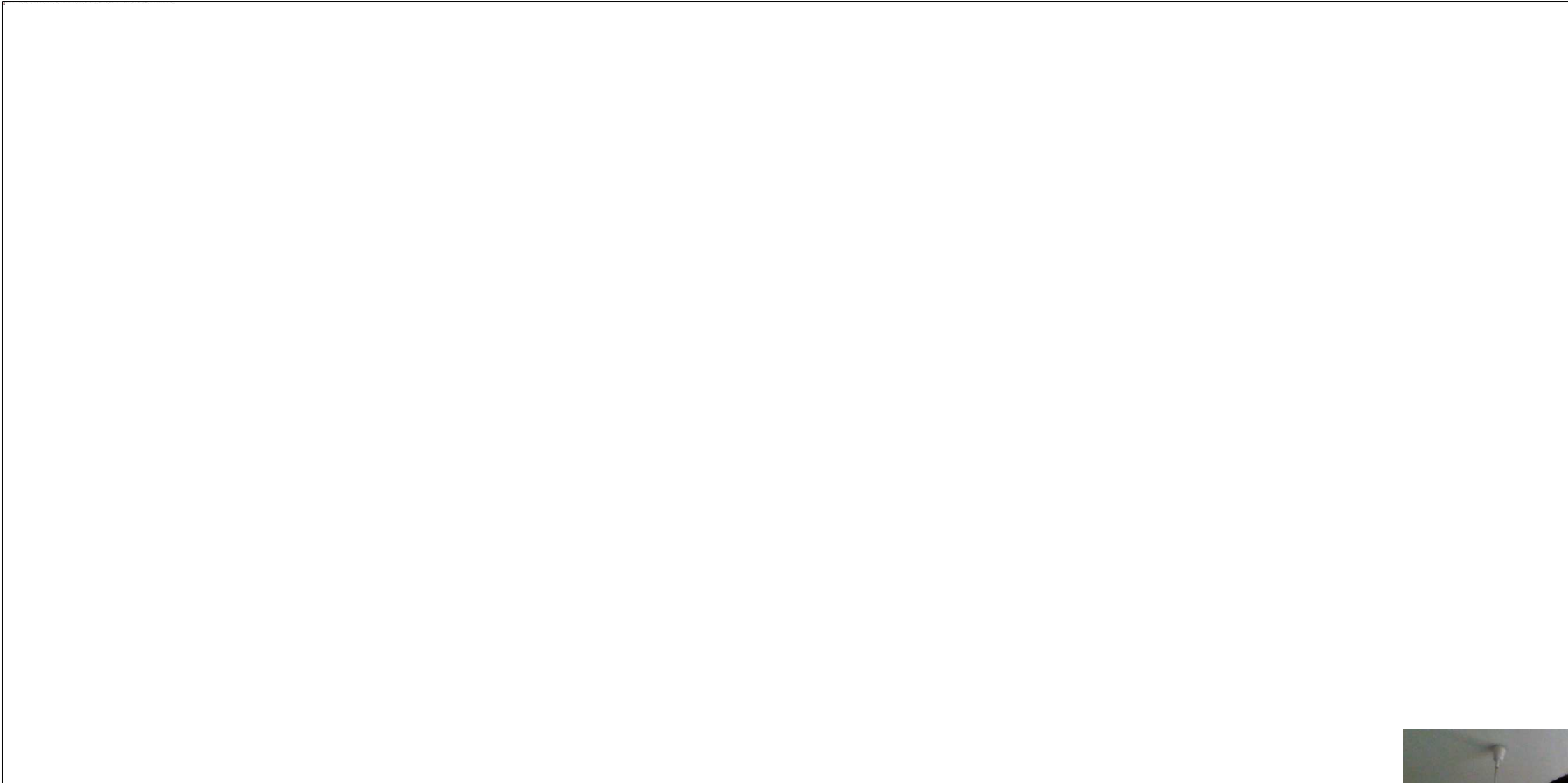
Yoshida. Nakabayashi
Van Meerbeek





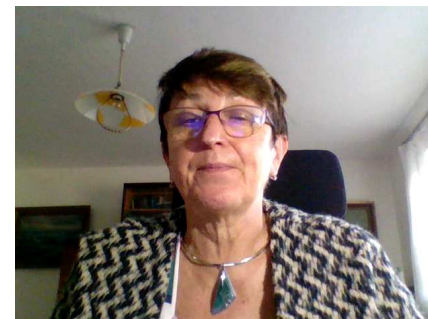
35% - 37% phosphoric acid
silica particles
blue dye



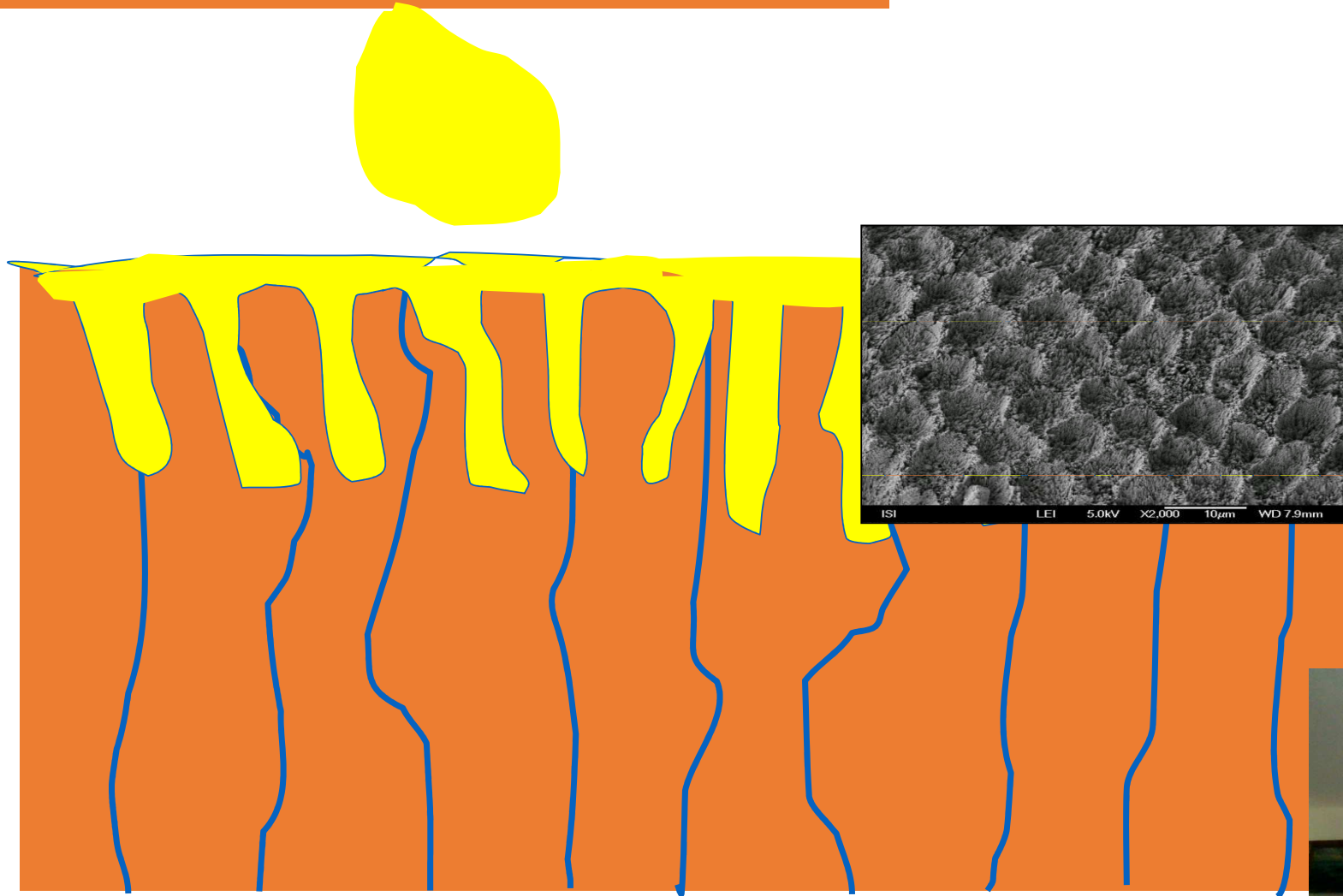


Adhesion

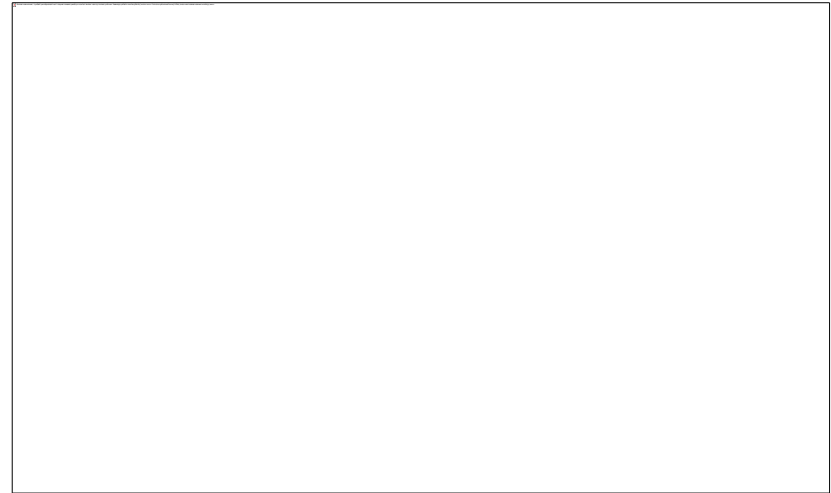
- Mechanical adhesion
- Specific adhesion
 - Intermolecular forces
 - Chemical binding



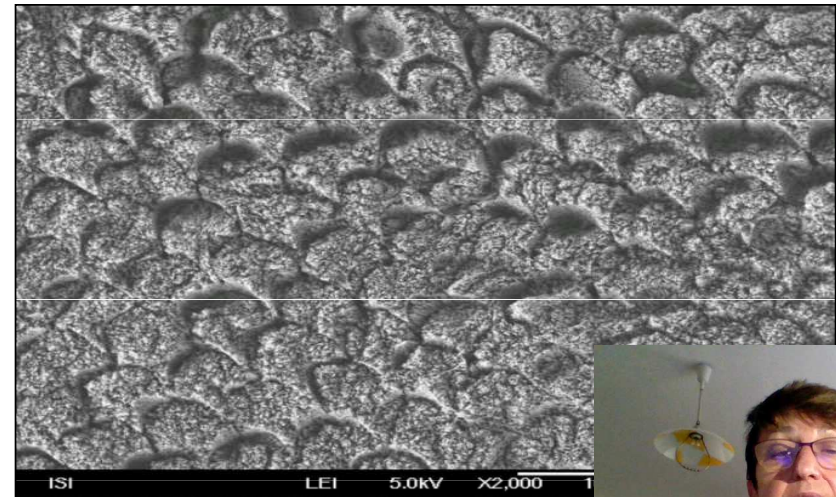
Enamel



Acid on aprismatic enamel

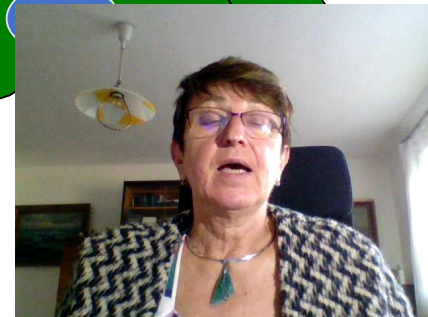
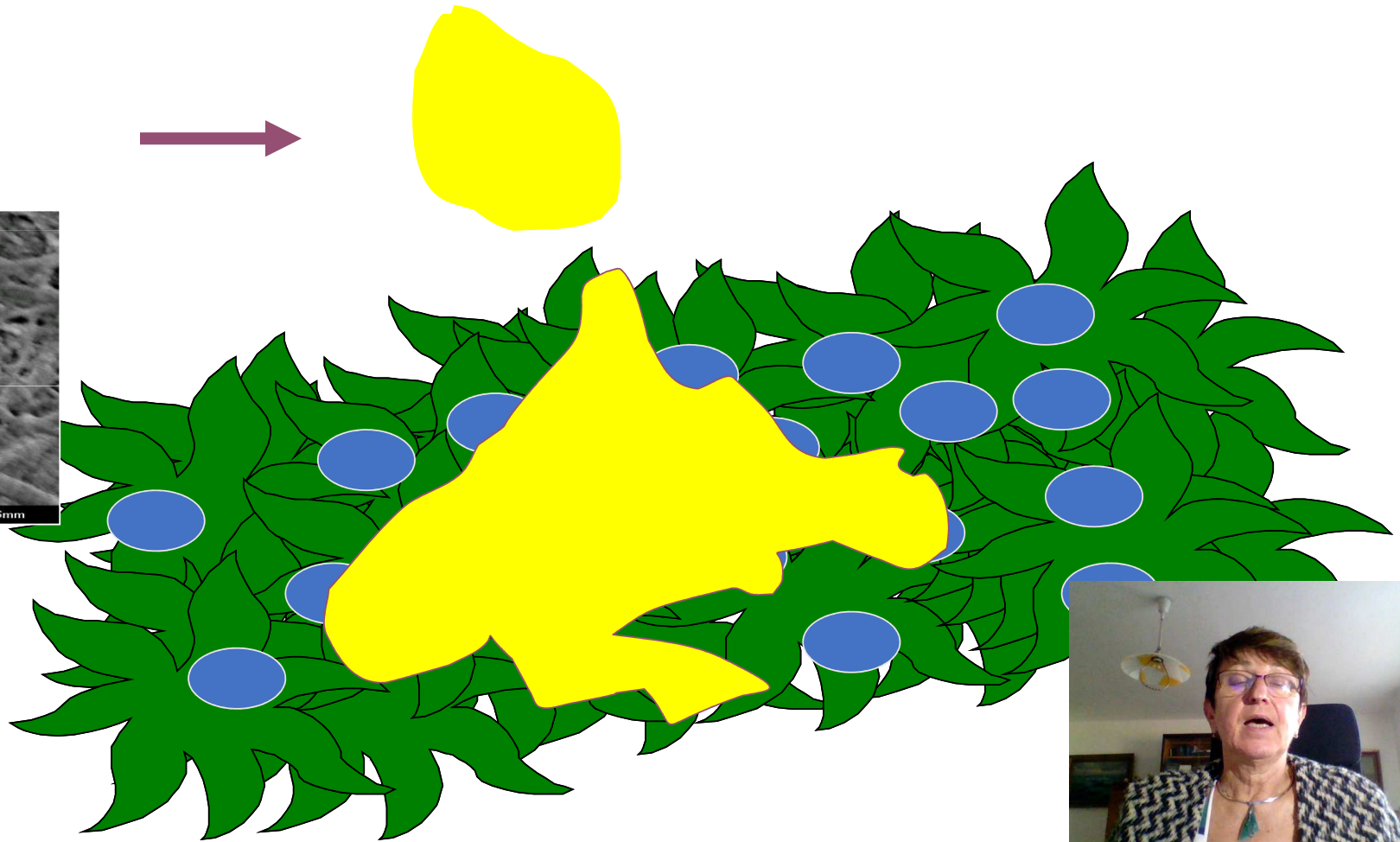
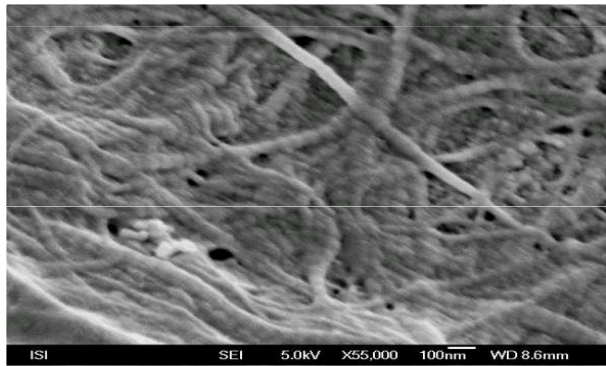


Acid on prismatic enamel



Dentin

Bonding agent



Adhesive system connects resin to enamel and dentin

- Bond is a hydrophobic resin principally of the same composition as composite filling material but without the filler or with a small amount of filler. It works in enamel. In dentin primer is necessary before bond.

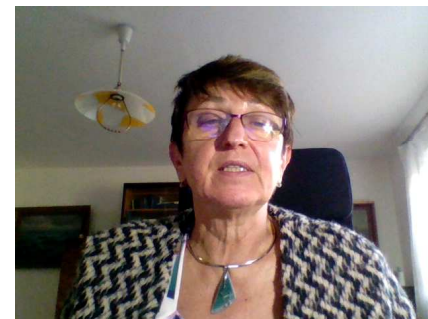
Why?



Dentin – special composition

- More water – always wett
- Less minerals
- Low surface energy
- Smear layer

Composite is hydrophobic, we need hydrophilic substance



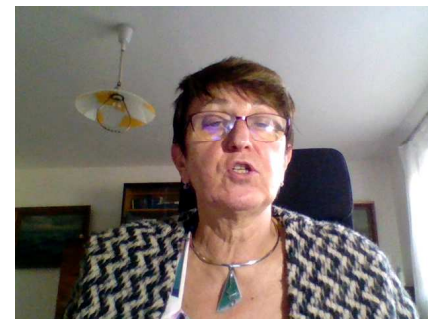
Adhesive systems contain resin monomers

- Hydrophobic monomers - bond works in enamel it does not work in dentin without primer
- Amphiphilic monomers – hydrophobic + hydrophilic part - in primer

Primer is necessary for dentin.

The hydrophilic part flows into dentin (tubules, spaces in collagen network) and keep the collagen network open, the hydrophobic part of primer binds to hydrophobic bond that flows into dentin pretreated with primer-

If primer applied on enamel – residual of water can be removed.



Adhesive systems contain resin monomers

Primer:

4-META •

HEMA •

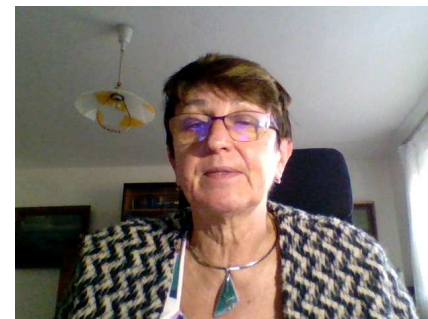
TEGMA •

PENTA P •

5-NMSA •

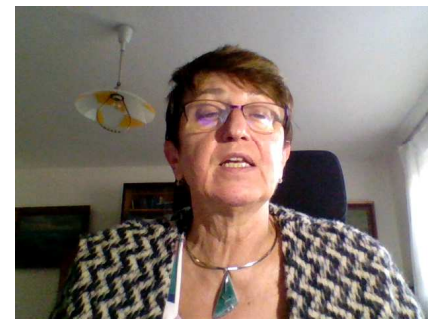
Bis-GMA

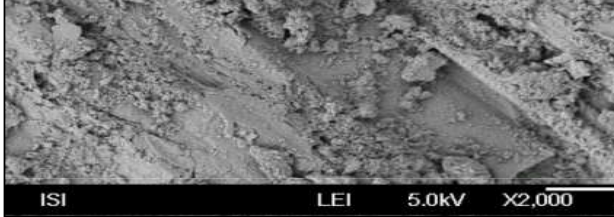
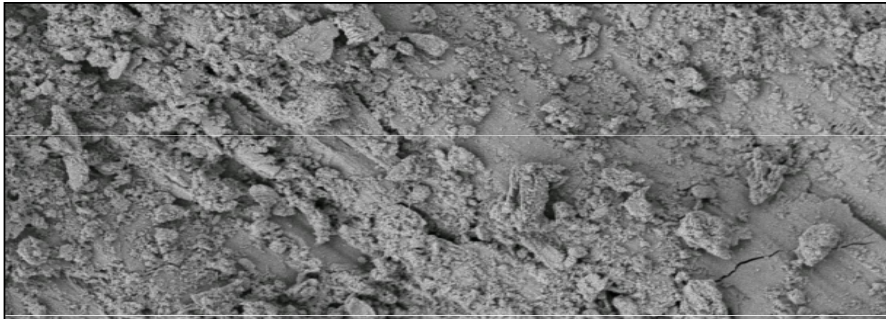
Bond: Bis-GMA or other dimetacrylates. Hydrophobic.



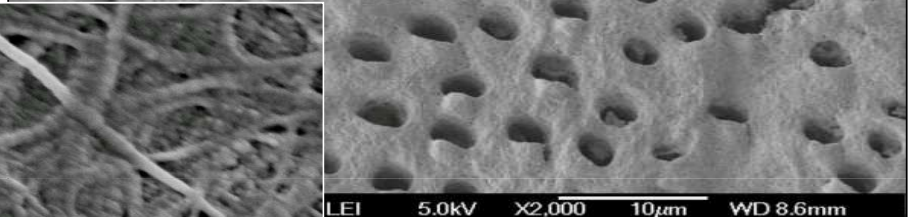
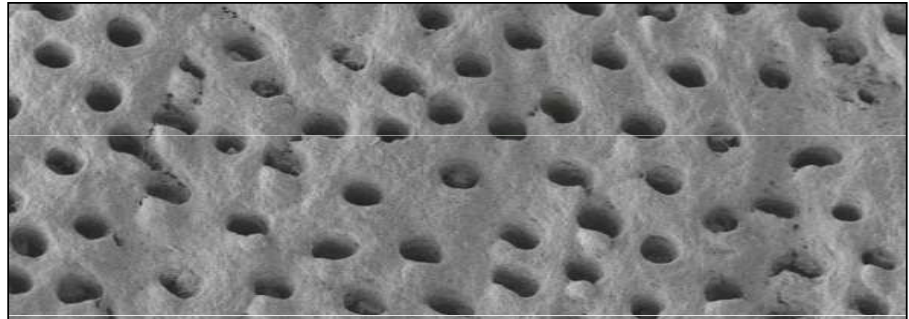
Dissolving agents

- Aceton
- Alcohol
- Water
- Water/alcohol

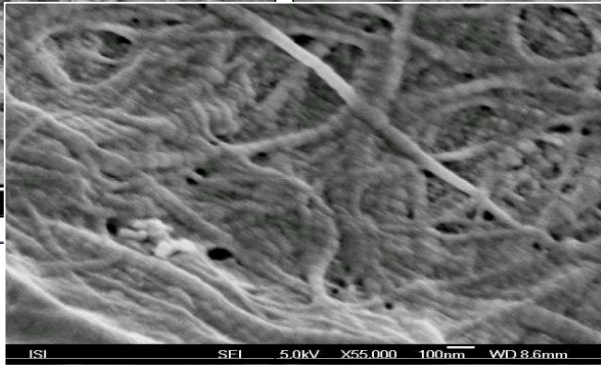




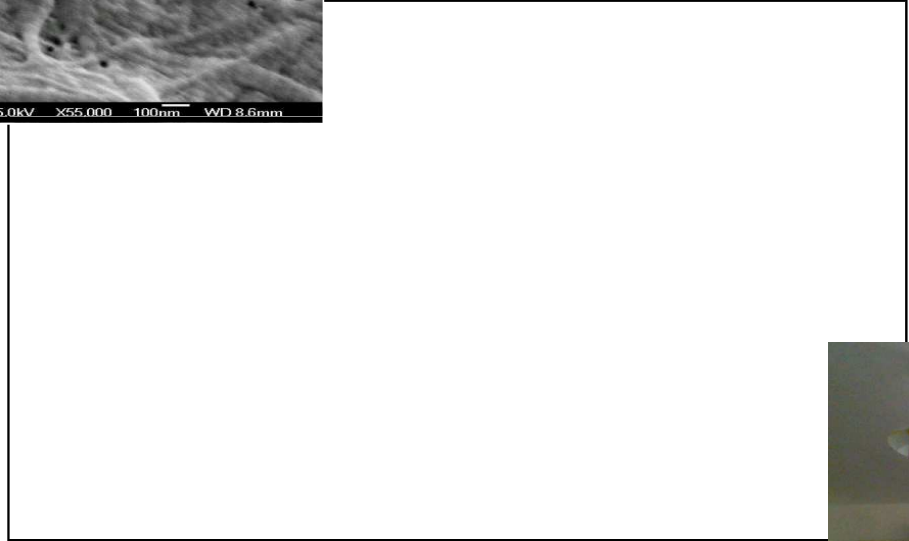
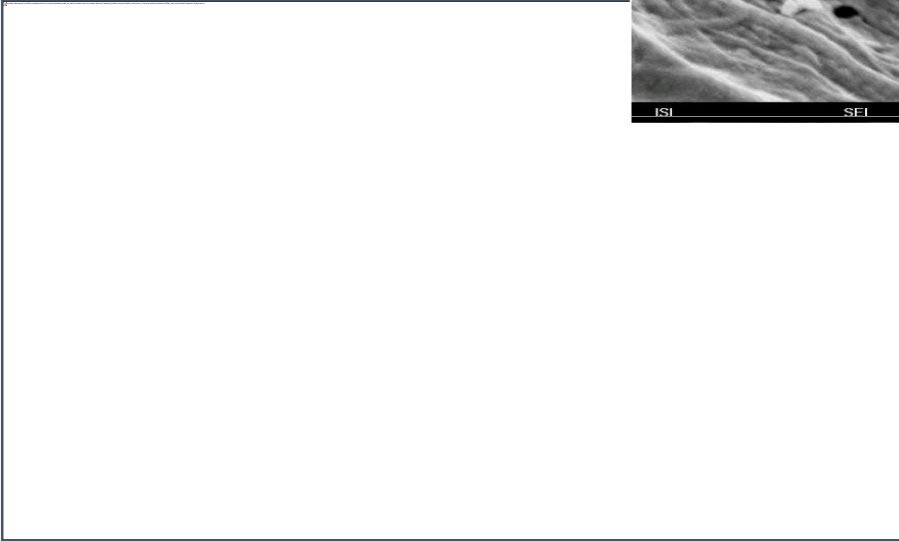
ISI LEI 5.0kV X2,000



LEI 5.0kV X2,000 10µm WD 8.6mm

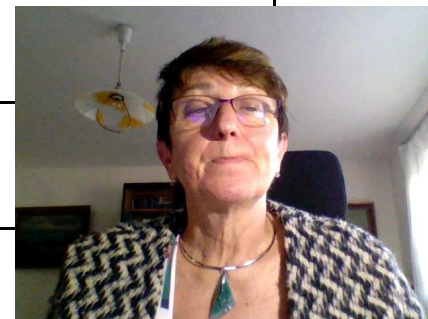


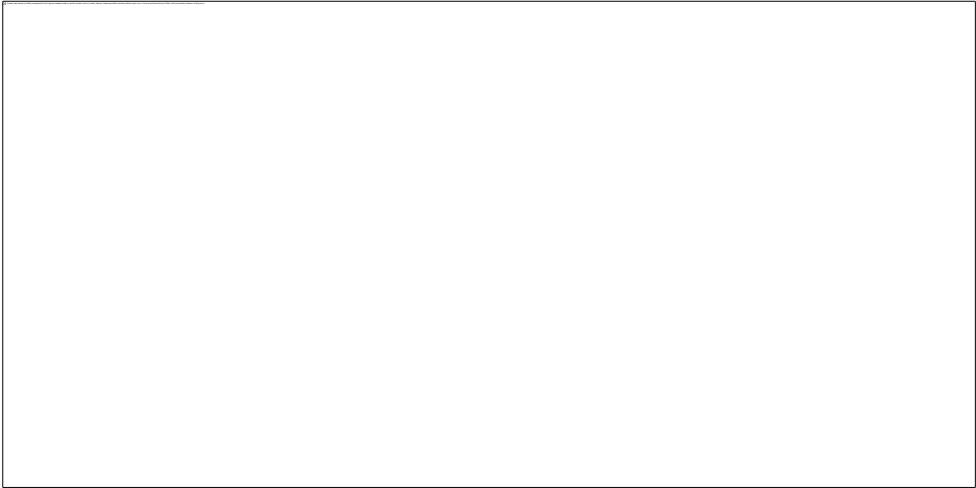
ISI SEI 5.0kV X55,000 100nm WD 8.6mm



Clinically oriented classification of the adhesive systems acc to number of steps

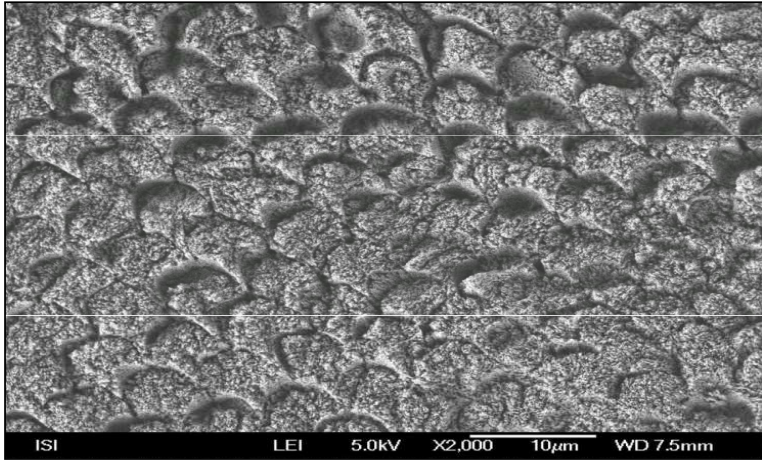
Acid etching	Rinsing	Priming	Bonding
Acod etchin	Rinsing	Priming a bonding	
Selfetching priming			Bonding
Selfetching bonding)			



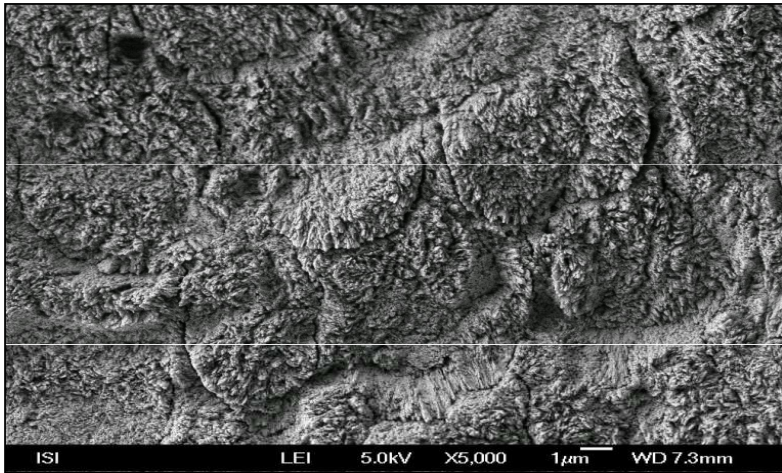


Self-fetching bonding agents

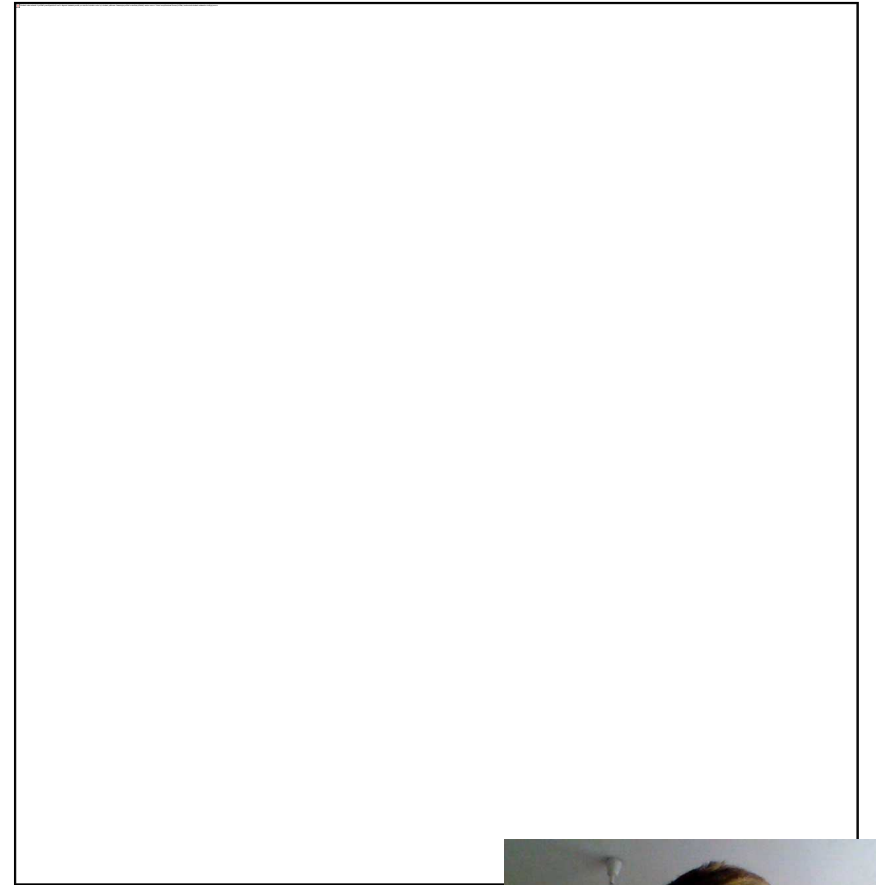




TE – Total etch,
ERA



SE – Self etching
SEA



Two steps selfetching agents

- Acidic hydrophilic primer – evaporation of the solvent, penetration, dissolving of the smear layer
- Hydrophobic bond – sealing of the surface



One step selfetching agents

- More vulnerable bonding, risk of hydrolysis

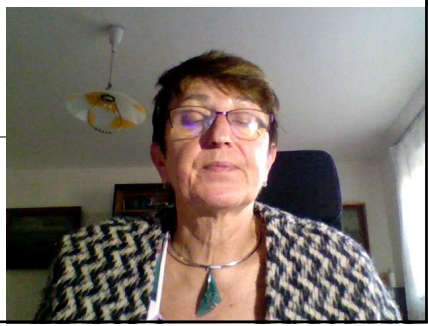
FAKT !!

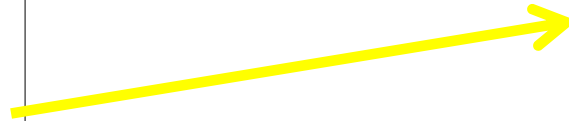
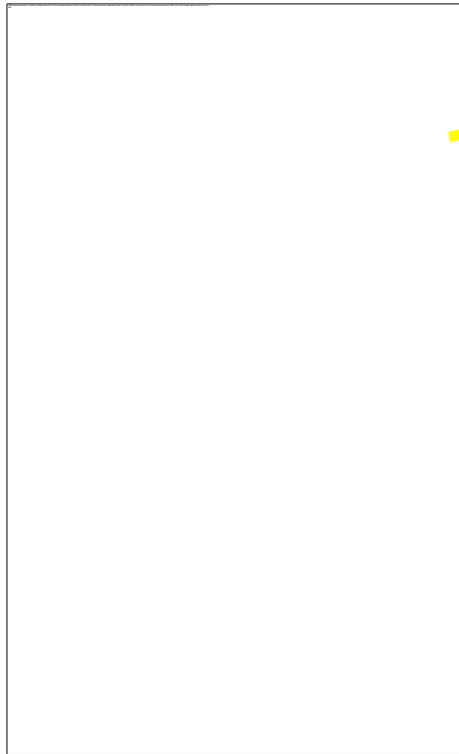




pH of the adhesive system
thickness of the hybrid layer

Source: Dudek M. Adhezivní spoj a adhezivní systémy I. LKS 11/2013





Colagen fibers with interfibrilar and Intrafibrilar crystals od hydroxyapatite

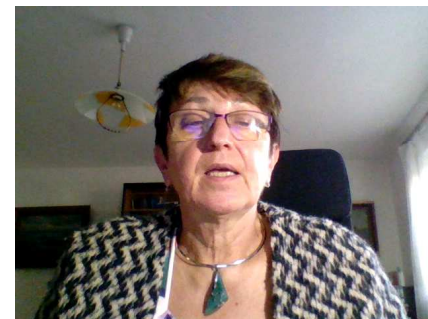


Colagen fibers with intrafibrilas crystals of hydrpoxyapatite only



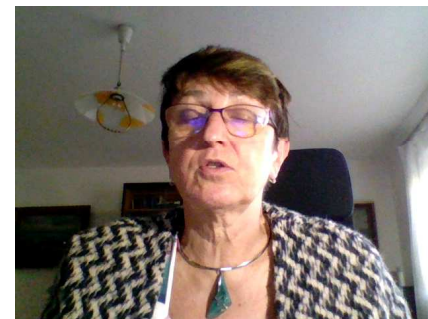
Colagen fibers without crystals of hydroxyapatites

Zdroj obrázku: Dudek M. Adhezivní spoj a adhezivní systémy I. LKS 11/2013

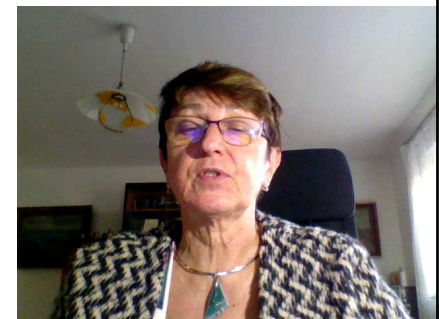


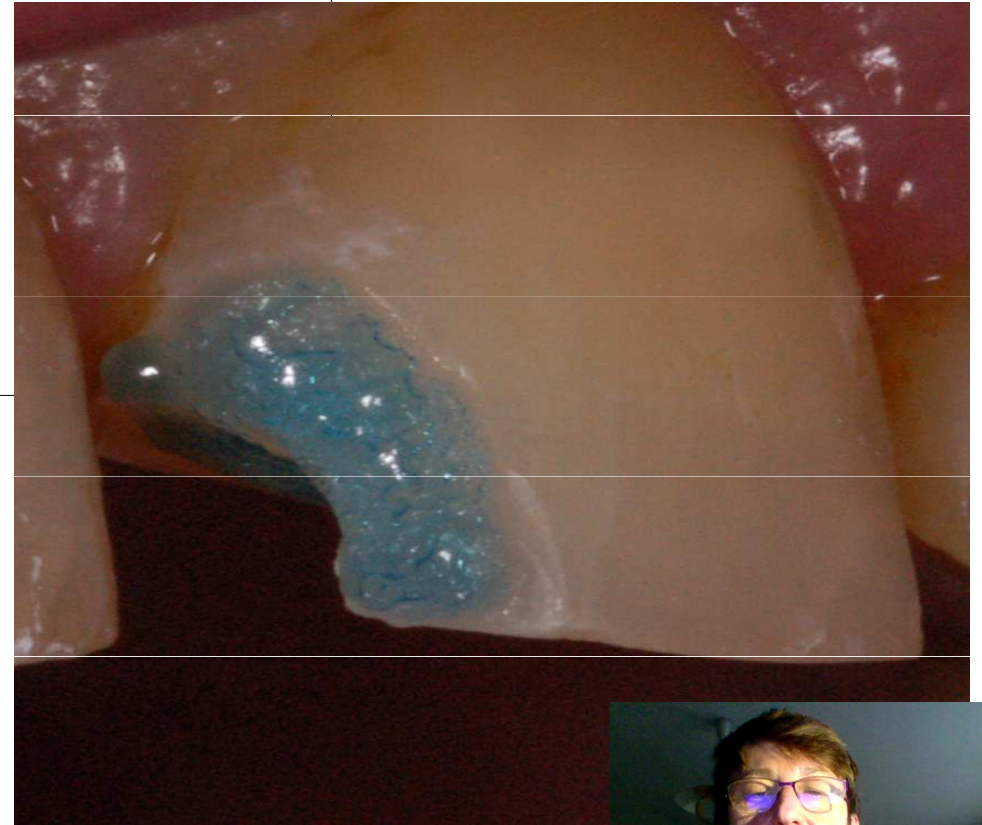
Importance of hydroxyapatite

- Protection of collagen against hydrolysis
as well as enzymatic degradation of collagen (due to activation of matrix metalloproteinases)
- Strong mineral acid is dangerous for good long term bonding
- Chlorhexidin for one minute can stabilize collagen



Enzymatic degradation of collagen

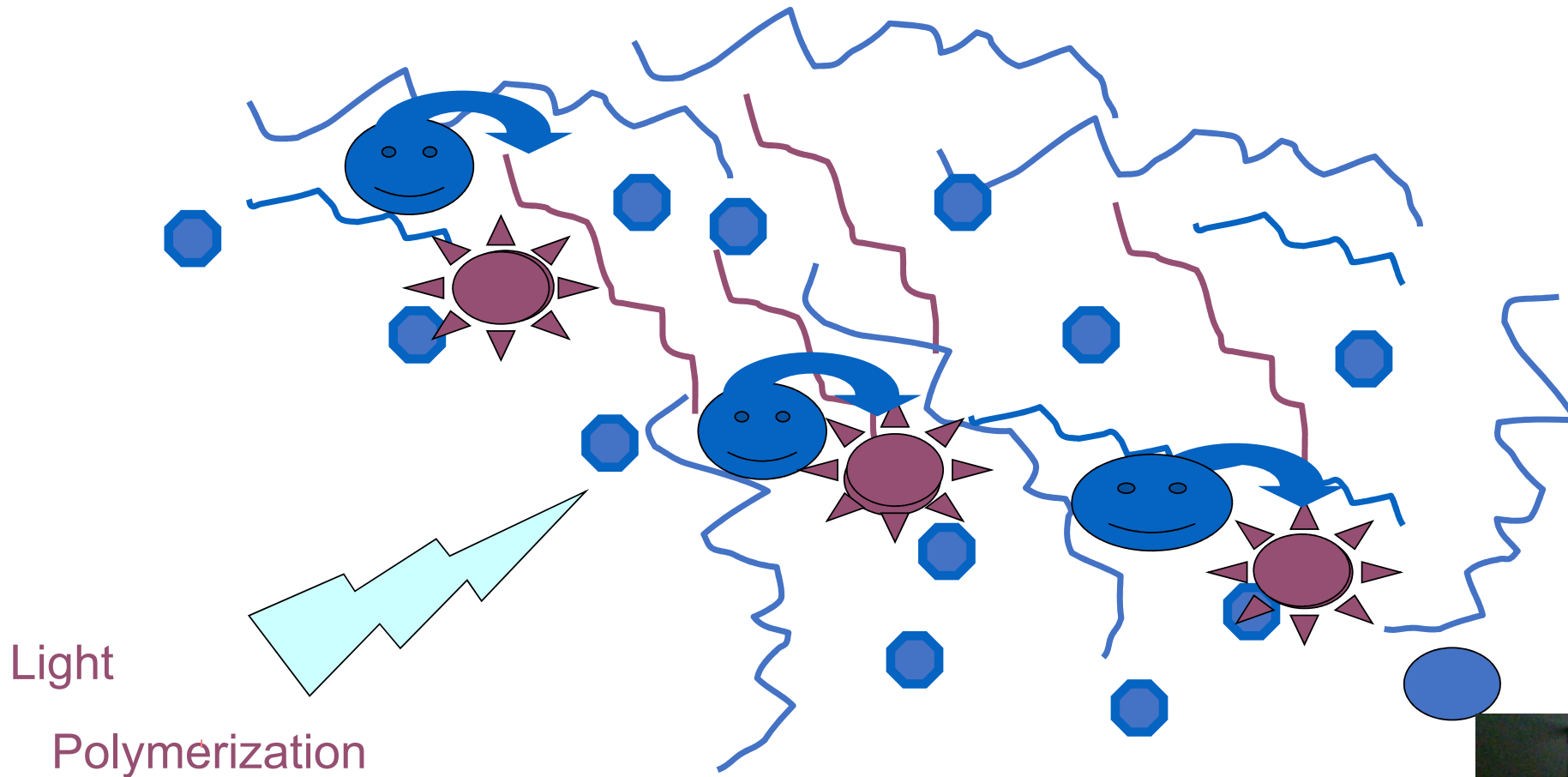




Factors affecting quality of bonding

- Structure and composition of hard dental tissues
- Quality of their surface – esp. presence of smear layer, contamination with moisture, saliva and blood
- Configuration factor – C- factor
- Mechanical loading of the adhesive connection
- Oral environment and external chemical materials (tooth pastes, asntiseptics, bleaching agent rtc.)

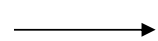




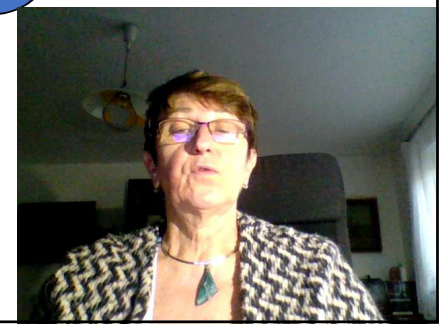
Light

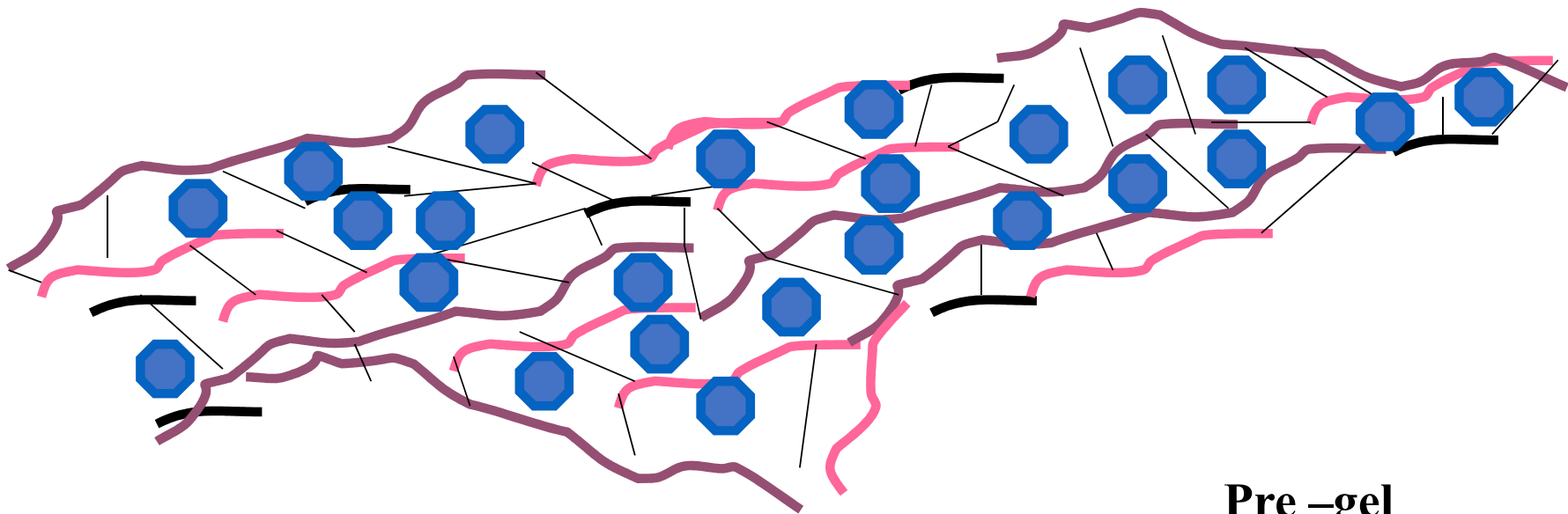
Polymerization

Monomer



Polymer





Pre -gel
Gel
Post -gel



Three phases

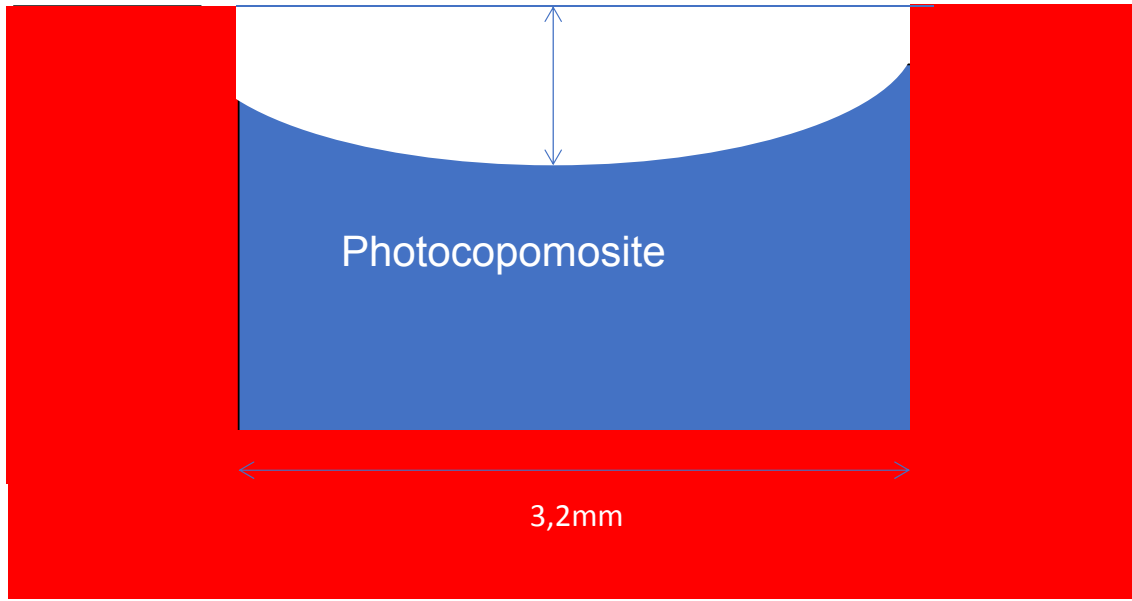
Phases

- Pre-gel – material is soft
- Gel-point – material became hard
- Post –gel – material is not soft, postgel shrinkage





3mm

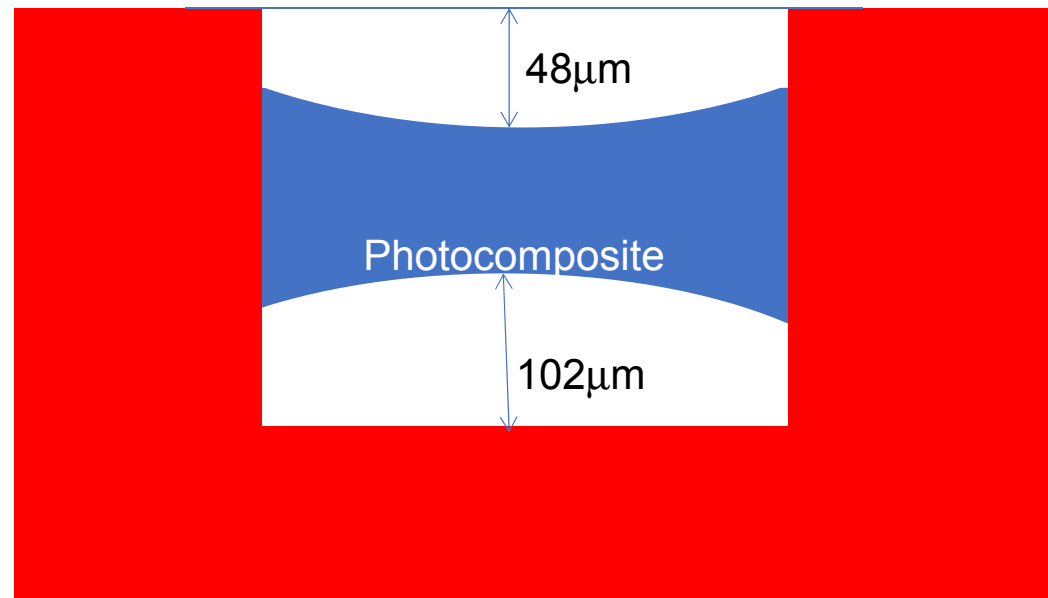


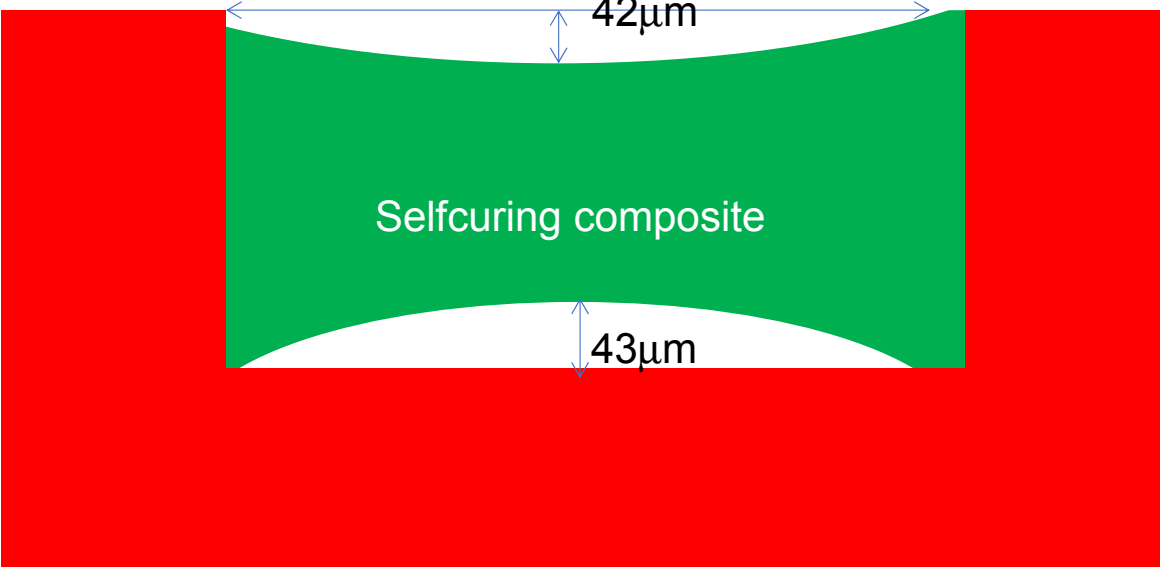
Photocopomosite

3,2mm

8,5mm







Polymerization shrinkage

- Deformation of material – free surface
- Forces on walls where the material is connected to the walls
(polymerization stress)

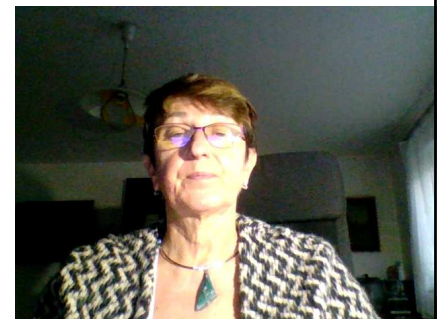
Possible consequences:

Gap formation or cracks in hard dental tissues



Polymerization stress depends on

- Quality of the material
- C- factor
- Mode of application
- Mode of polymerization



Polymerization stress depends on

- Quality of the material
- C- factor
- Mode of application
- Mode of polymerization

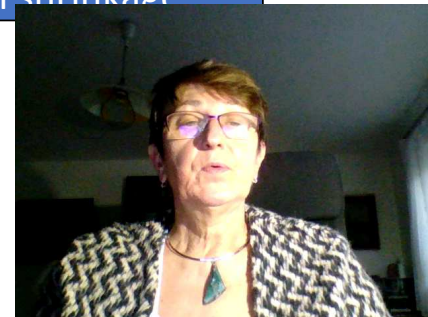


High content of filler increases the modulus of elasticity
High modulus of elasticity increases the polymerization stress
High content of filler decreases the polymerization shrinkage

Polym. Stress

Modulus of elasticity

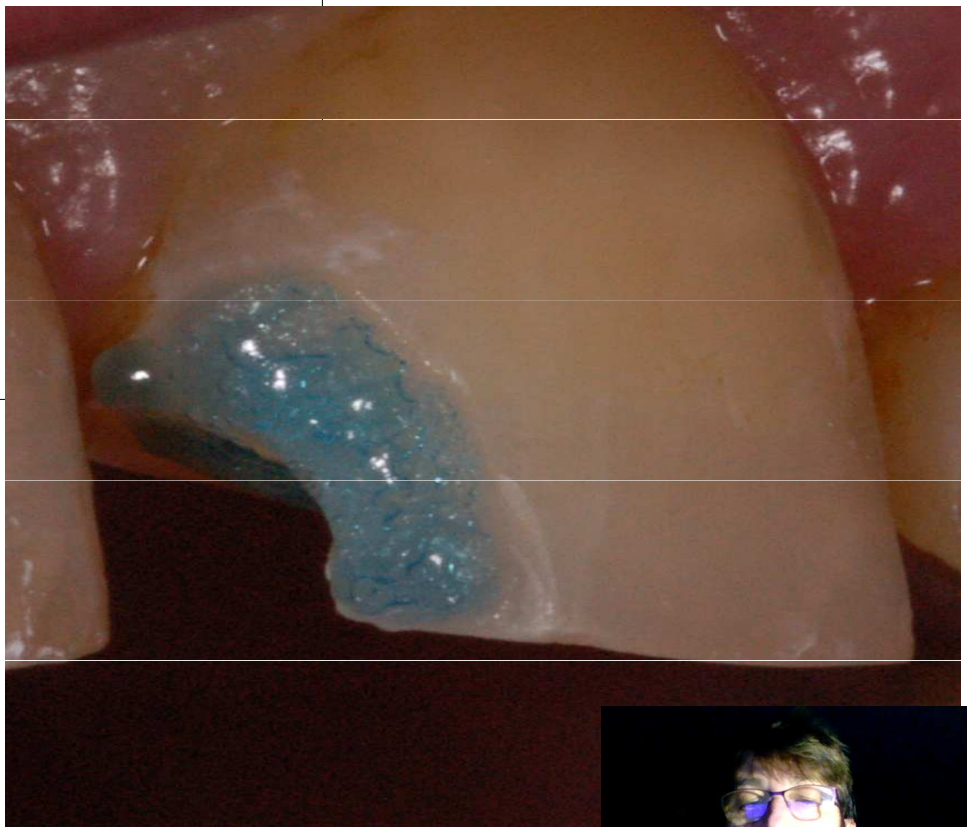
Polymerization shrinkage

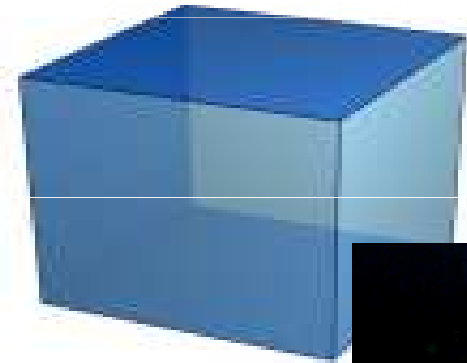
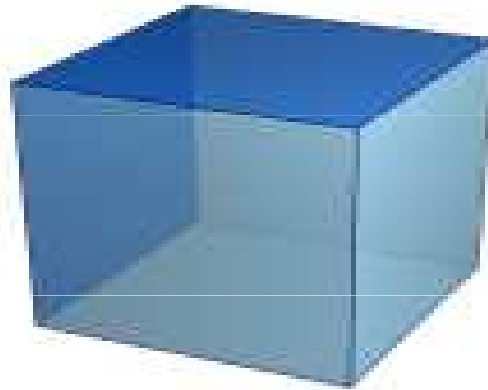
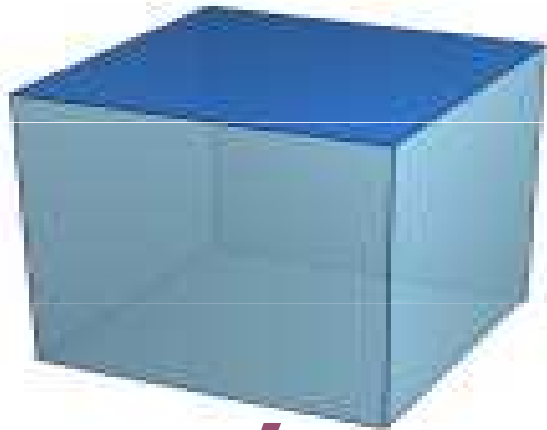


Polymerization stress depends on

- Quality of the material
- C- factor
- Mode of application
- Mode of polymerization





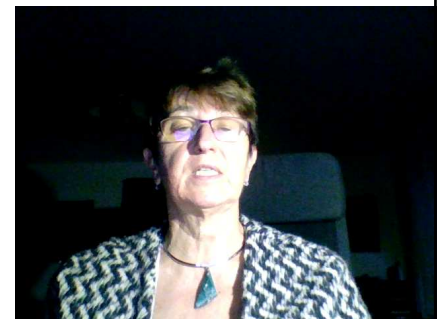


Bonded area : Free area
1:1 and less - optimal



Polymerization stress depends on

- Quality of the material
- C- factor
- **Mode of application**
- Mode of polymerization



Mode of application

- **Incremental technique**

Layer by layer with big free surface

- *Importance of flowables*

Thin layer of flowable first –big free surface

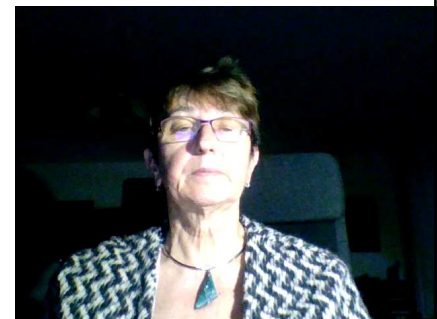
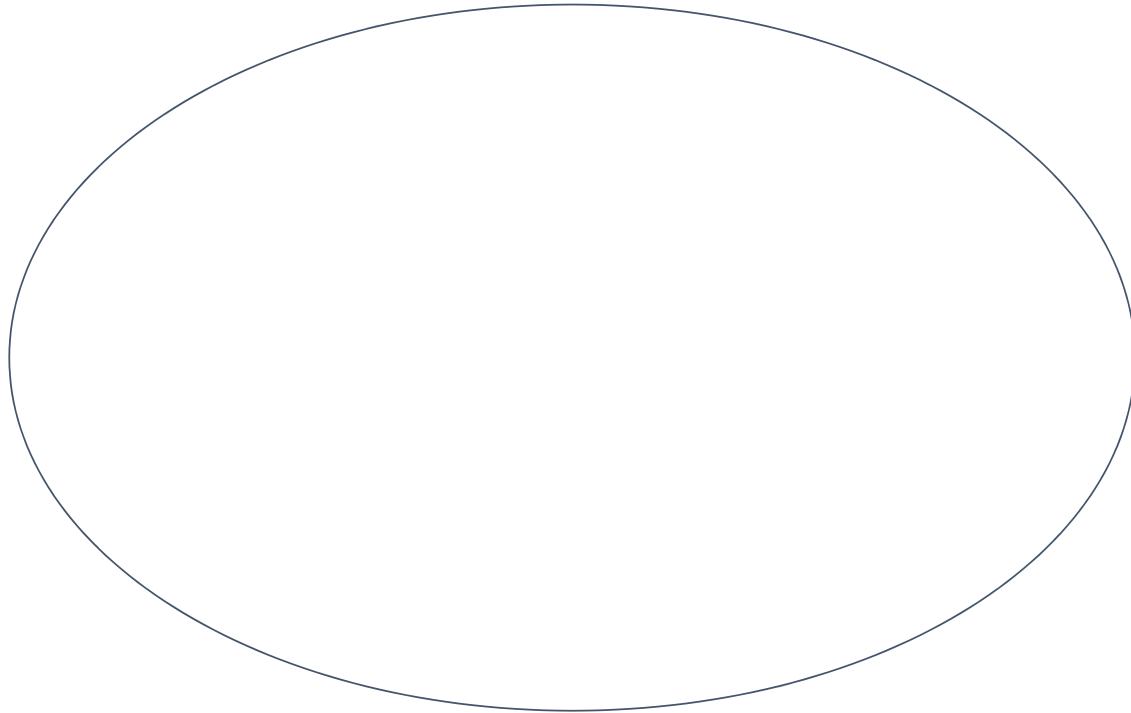
Good marginal adaptation

Compensation of the stress of the other layers

Bulk fill materials do not solve the problem with polymerization stress

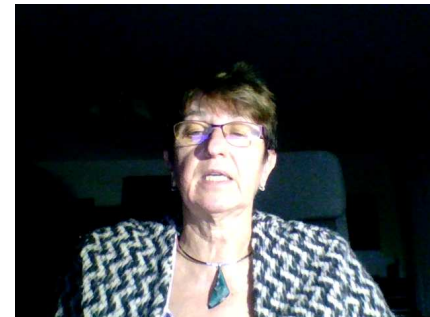


Placement of the material

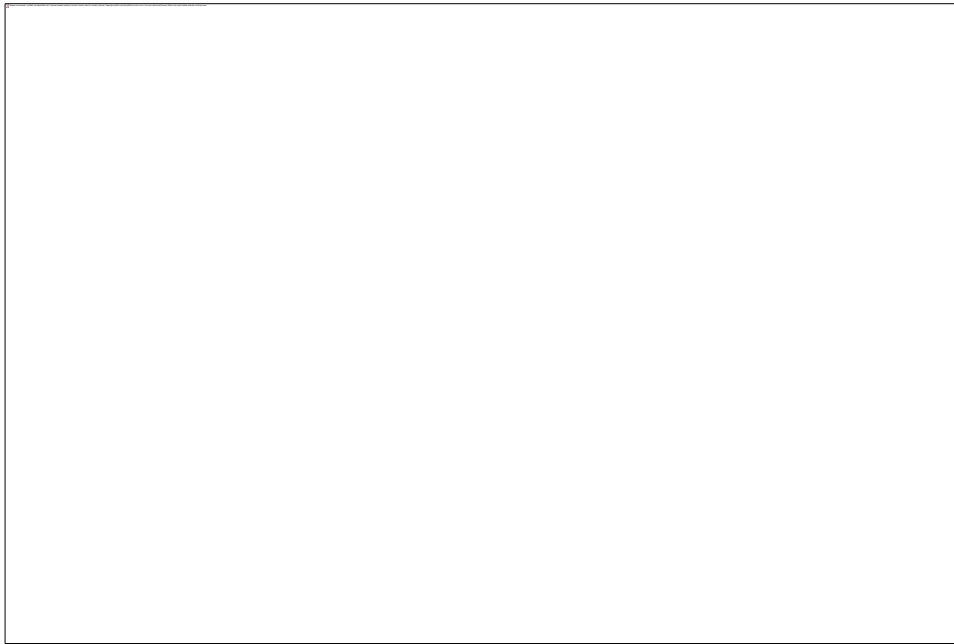


Placement of the material

- Photocomposite
 - Thin layer with the maximal free surface (with respect of C-factor of each layer)
 - Combination of materials of various viscosity
 - GIC + photocomposit (two visits better)
 - Increment of cured material into the soft non cured material



Consequences of high C- factor



← White line around the filling



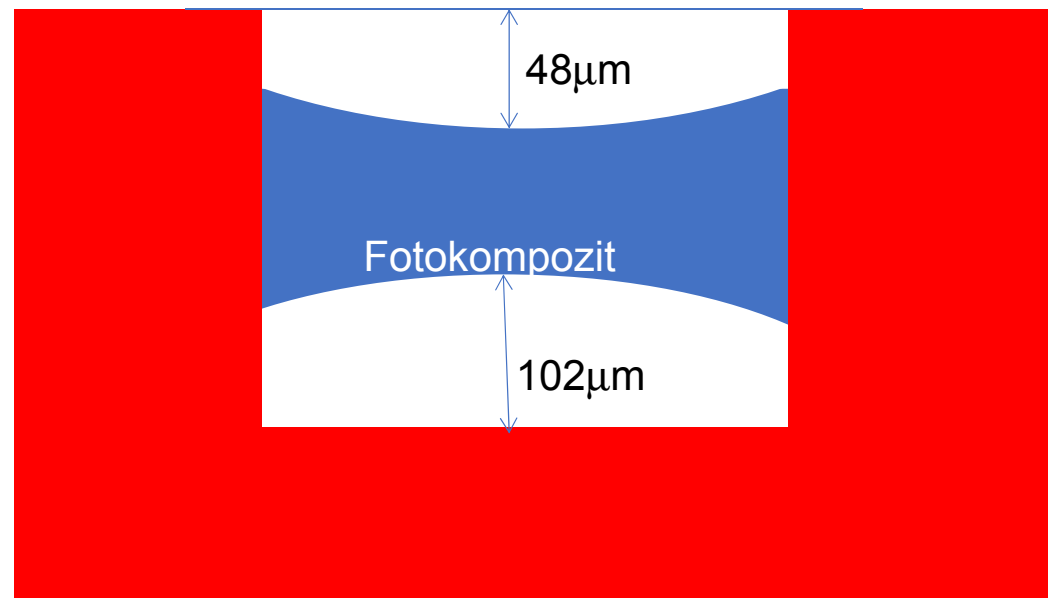
Sealing of the filling . Acid etching around the cavosurface margin,
application of the unfilled resin

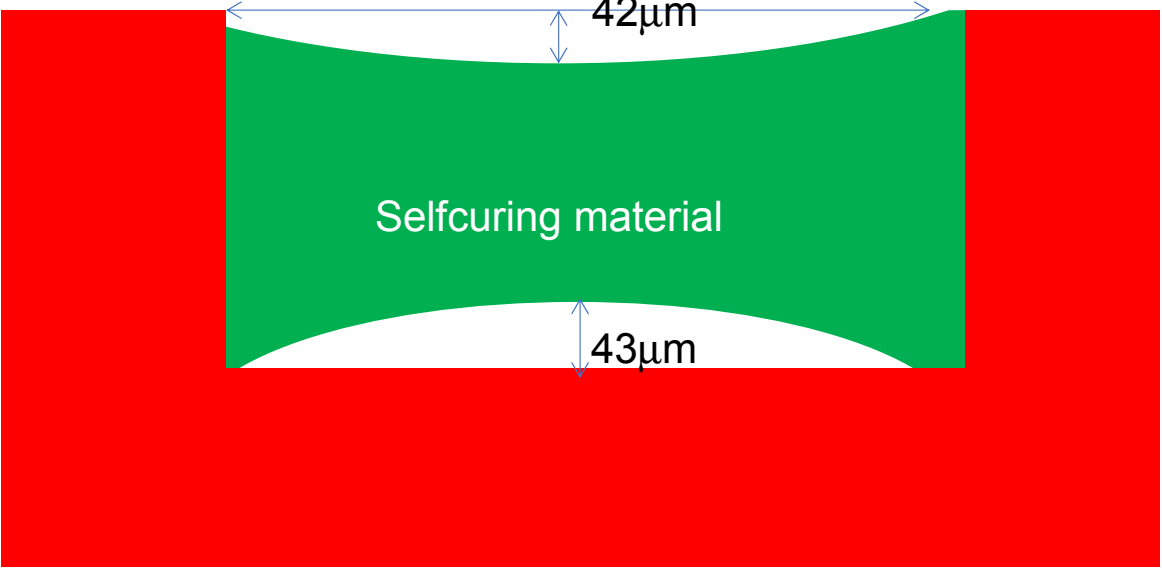


Polymerization stress depends on

- Quality of the material
- C- factor
- Mode of application
- **Mode of polymerization**







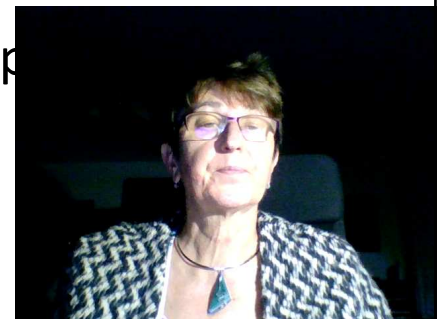
Duration of pre-gel phase

- Longer pre-gel phase is better for releasing of polymerization stress
 - Soft start
 - Combination of materials (selfcuring composite materials have longer pre gel phase)



Factor that influence the quality of bonding

- Configuration factor – C- factor +polymerization stress
- Structure and composition of hard dental tissues
- Quality of their surface – esp. presence of smear layer, contamination with moisture, saliva and blood
- Mechanical loading of the adhesive connection
- Oral environment and external chemical materials (tooth pastes, asntiseptics, bleaching agent rtc.)



Contemporary possibilities polymerization

- Quartz halogen units (halogen lamp)
- Plasma units
- LED units (diode – monochromatic light, need of more diodes)
- Laser (strictly monochromatic light)



Polymerization units – output energy

Quarz halogen

600 -800 mW/cm²

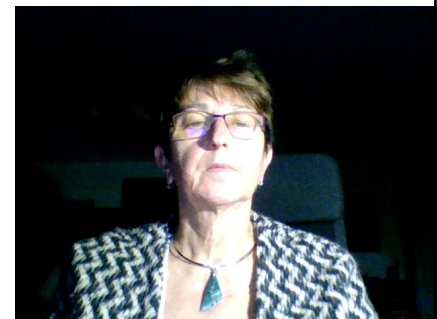
LED (3.generation)

1000 -1800 mW/cm² blue

50 – 100 mW/cm² purple

Plasma

1500 - 2000mW/cm²



Output energy and time of polymerization

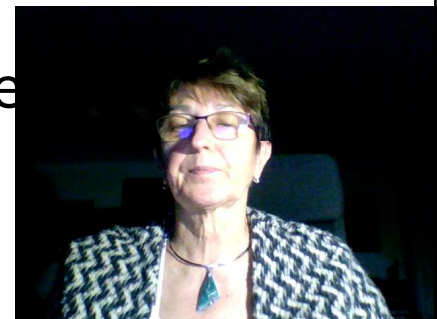
- Recommended power is 12000 – 16000 mJ/cm²

12 000 mWs/cm²
measured intensity mW/cm²

Time in seconds

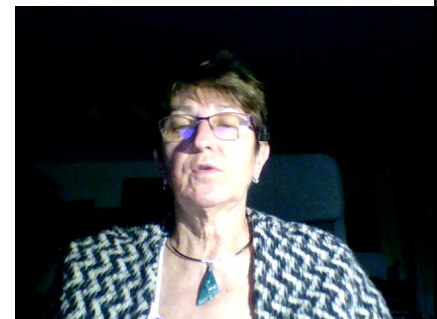
Usually 20 s

Radiometer is recommended



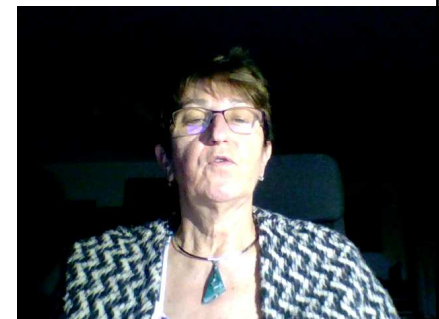
Photoinitiators

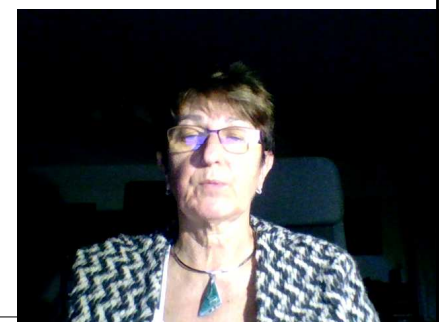
- Kacrchinon
CQ
- Phenylpropandion
PPP
- Trimetylbenzoylphosphinoxid TPO

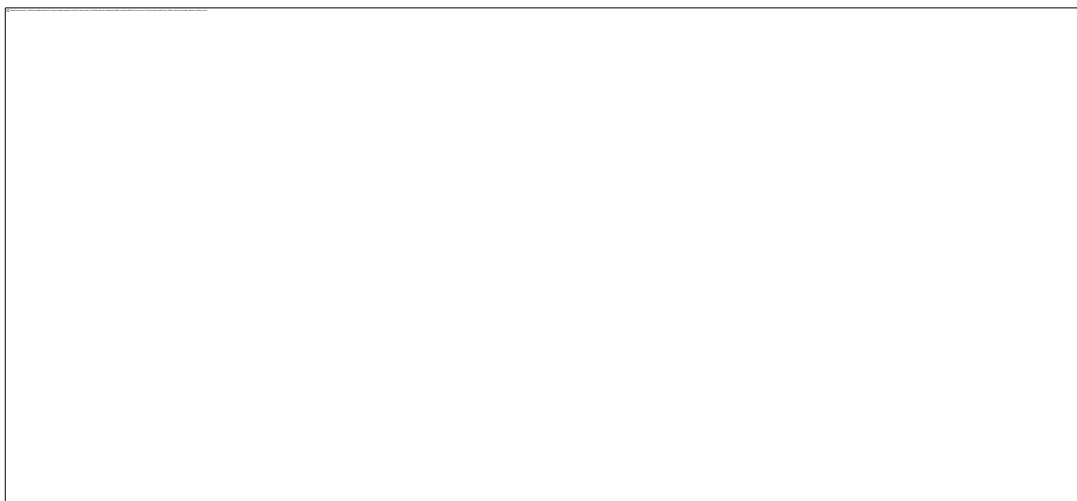
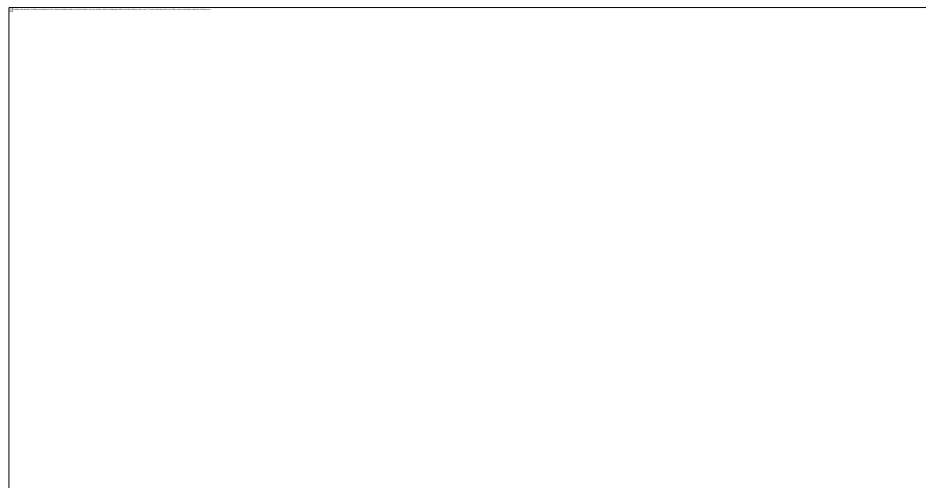
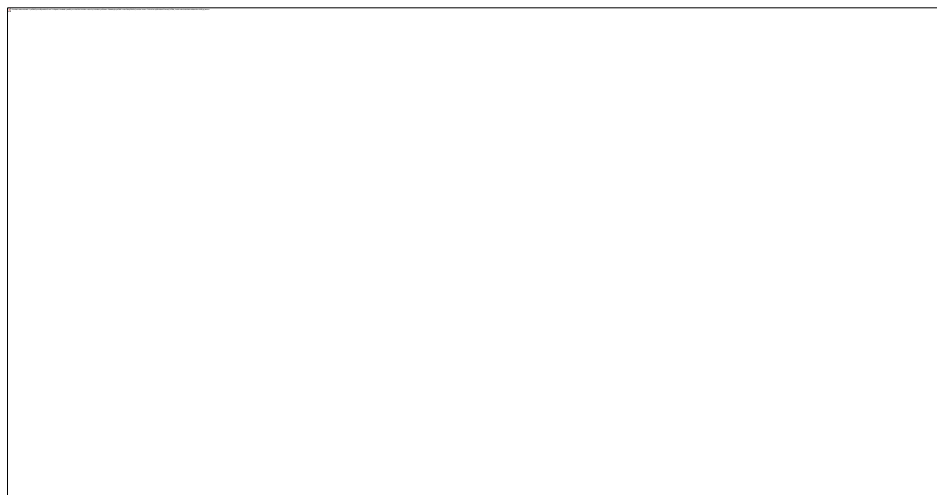


Absorbtion spectrum of fotoiniciators

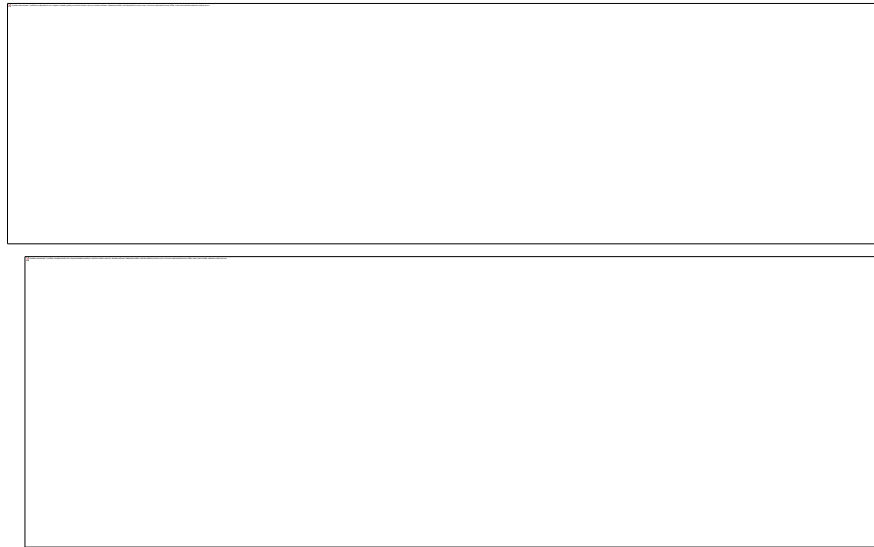
Photoinitiator	Absorbtion spectrum (nm)	Maximum (nm)
CQ	440 - 500	470
PPD	380 – 430	400
TPO	350 - 410	380







Light conductor

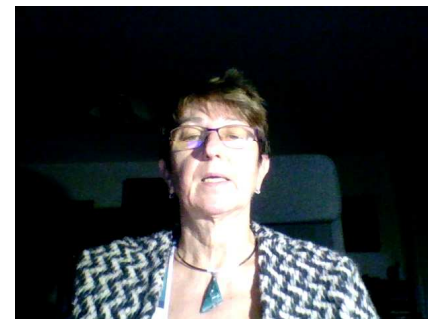


Standardní a kónický světlovod

Small area – higher concentration of output energy, but bigger dispersion

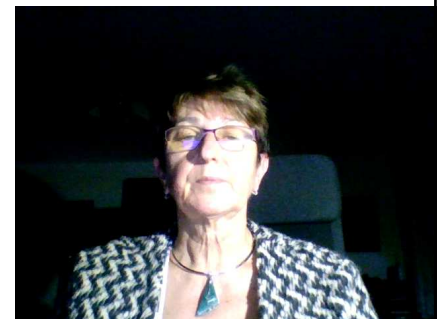
The average distance is 4 mm – 10 mm.

Standard light conductor – more reliable for daily is



Mode of curing

- Continuous curing at a constant intensity level: 40s of 500 mW/cm²
 - Continuous two step curing
 - 10 s 150 W/cm² then 750 mW/cm²
 - for remaining time
 - Two step ramp – low intensity level gradually increases (5-10s) to achieve a final high intensity
 - Puls delay
 - Low intensity short time, 100 - 300 mW/cm² unit is turn off. 3 min pause
 - Final curing 600 mW/cm²
- Othe factors for consideration
 - Shade
 - Increments towards dentin walls
 - Pulse delay technique is dedicated to the layer that contacts enamel



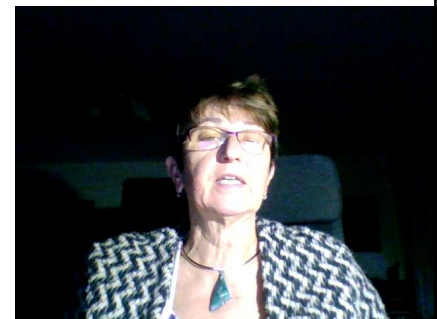
Flowables

- – marginální adaptation (material flows)
- - small polymerization stress – importance in incremental technique
- - block out of undercuts
- - small cavities, corrections



Composite materials with high viscosity

- Small polymerization shrinkage
- High polymerization stress
- Worse marginal adaptation

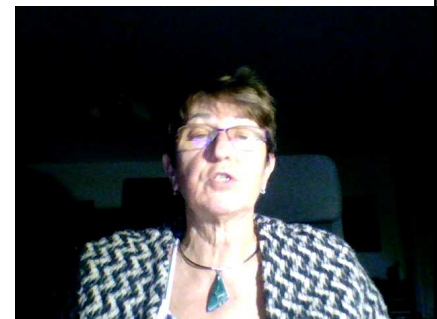


Bulk fill

- Application and curing in one bulk
- Higher amount of fotoinitiators
- Higher translucency
- The problem with polymerization stress is not completely solved

Group of various materials:

1. Flowables
2. Condensables
3. Sonic Fill (KaVo)



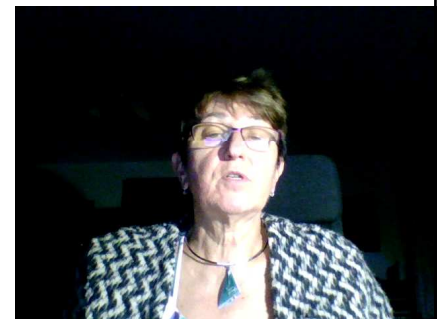
Sonic Fill

Big bulk up to 5mm (less - 4 mm is recommended)

Sonic „activation“ - vibration decrease viscosity

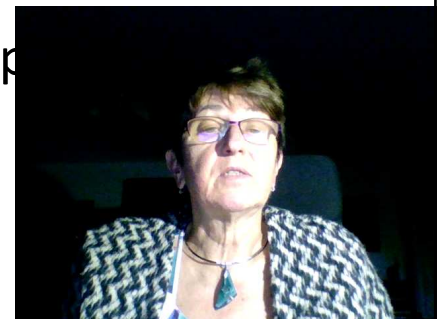
Internal dispersion of light

Long term experience?

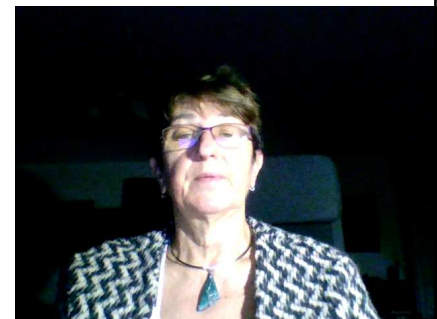


Factors that influence the quality of bonding

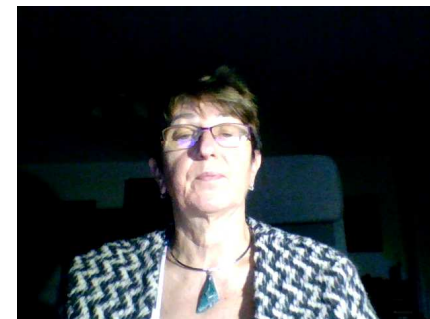
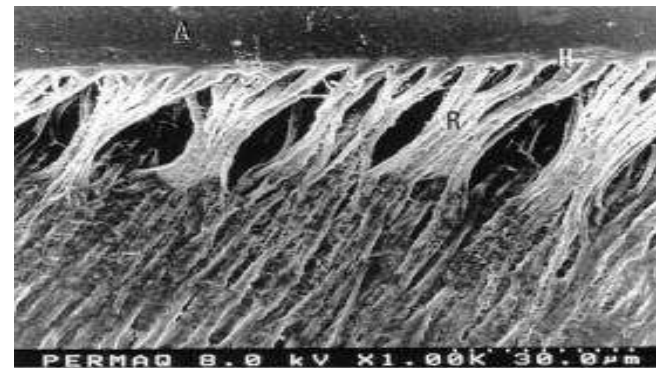
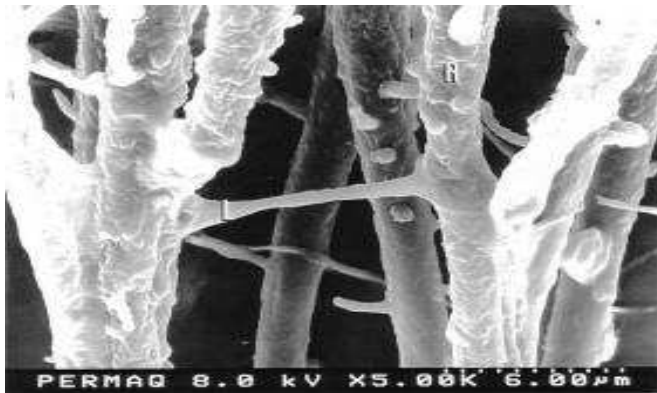
- Structure and composition of hard dental tissues
- Quality of their surface – esp. presence of smear layer, contamination with moisture, saliva and blood
- Configuration factor – C- factor
- Mechanical loading of the adhesive connection
- Oral environment and external chemical materials (tooth pastes, asntiseptics, bleaching agent rtc.)



Working procedure and variables affecting the bonding



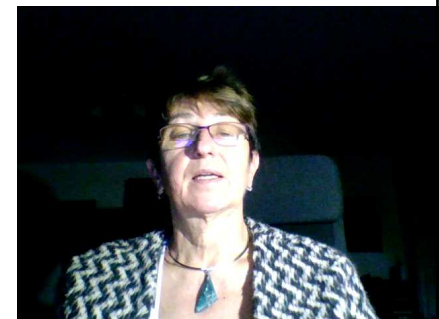
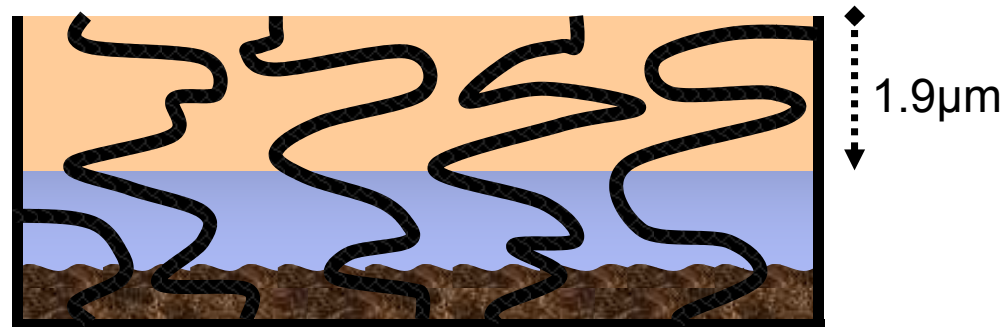
What affects the quality of bonding?



Variables that affect quality of bonding

1) Etching

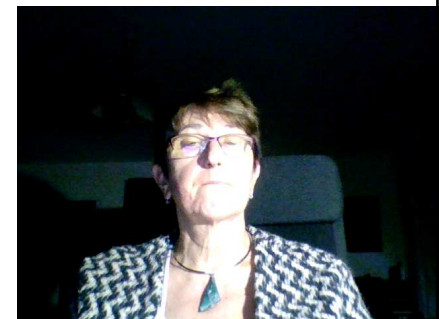
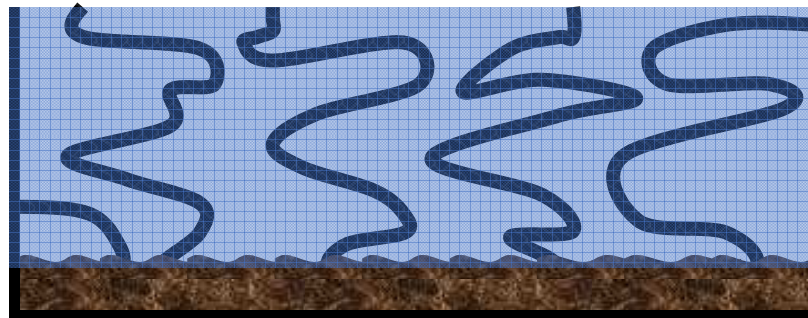
Etching too long can etch too deep, making it difficult for the resins to reach sound tooth structure.



Variables that affect quality of bonding

2) Drying dentin

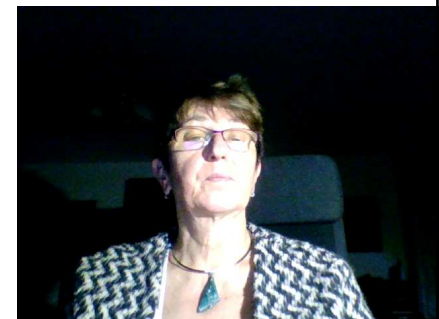
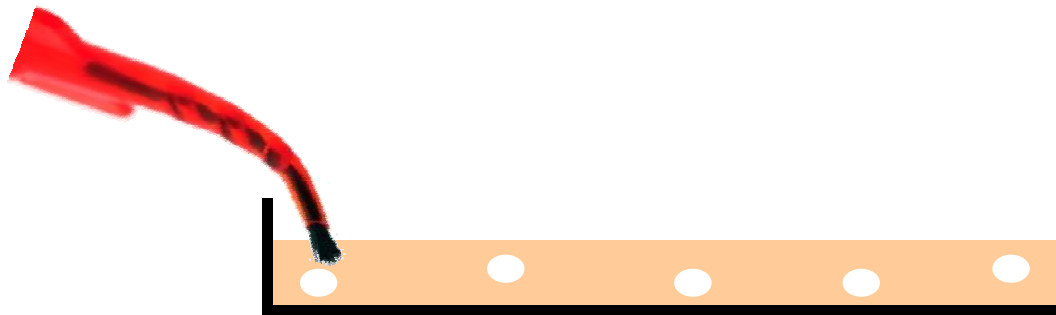
Over drying the dentin after etching can be very destructive to bond values with some adhesives.



Variables that affect quality of bonding

3) Application time

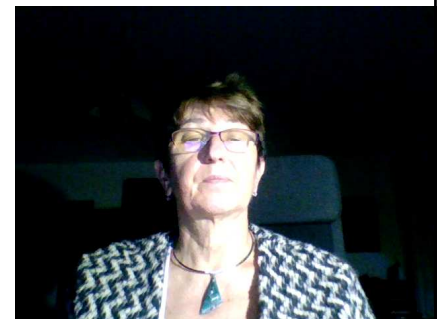
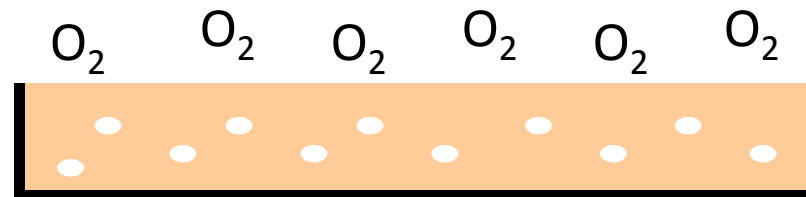
Too short of application time may not allow for proper volatilization of the solvents or complete resin hybridization. This is critical with self etching systems.



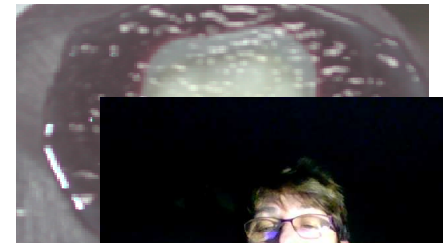
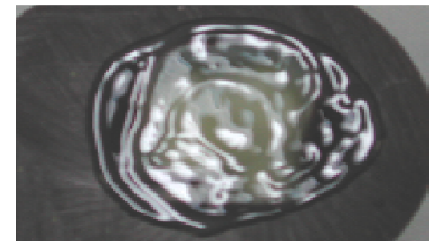
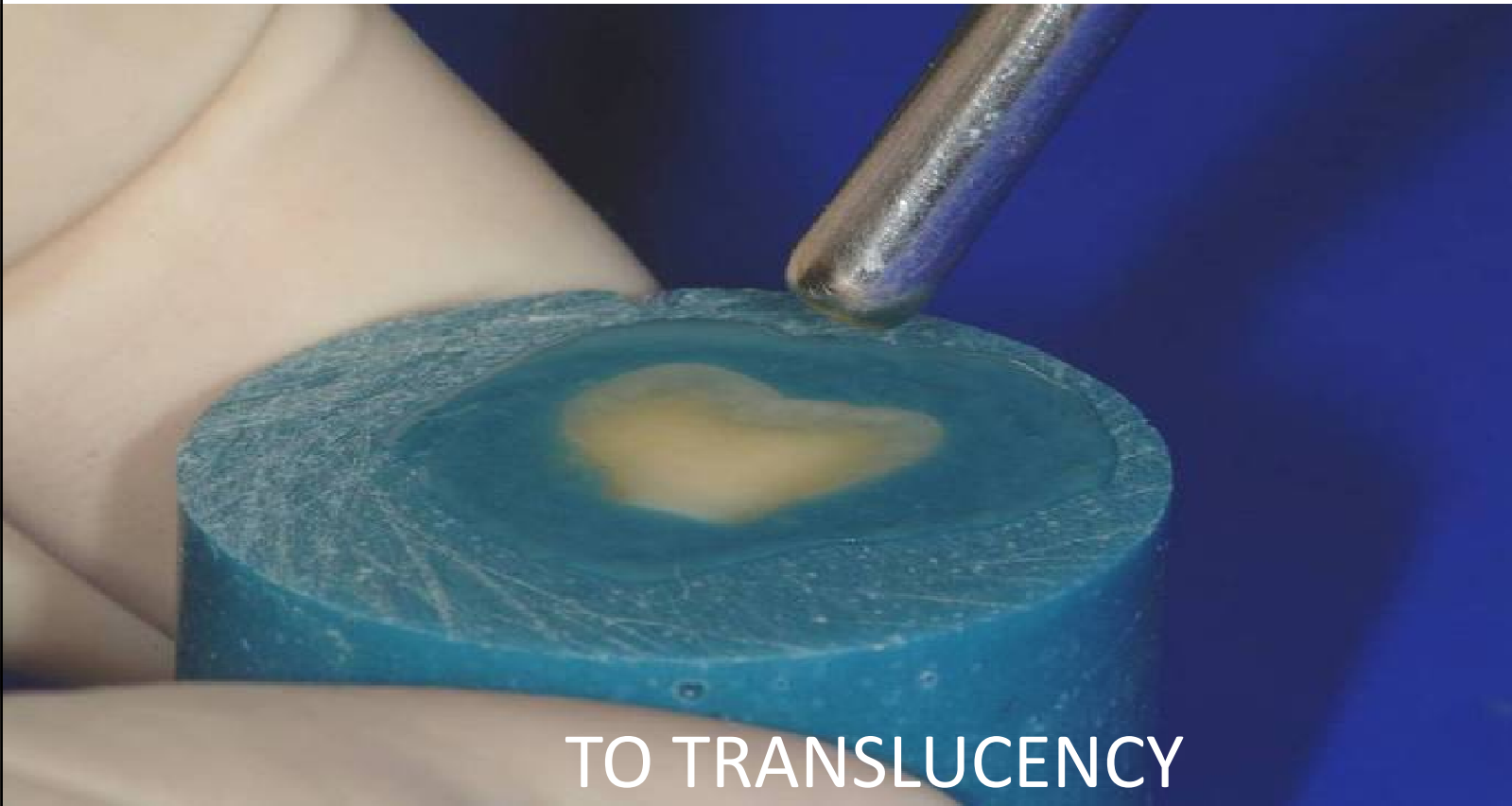
Variables that affect quality of bonding

4) Thinning / drying

Too thin of adhesive layer doesn't allow for proper curing due to oxygen inhibition. Too thick and the adhesive may still contain solvents.



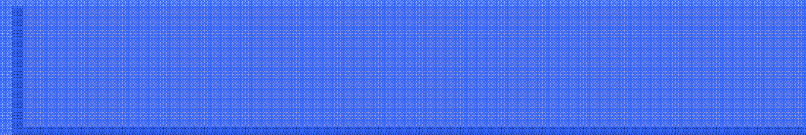
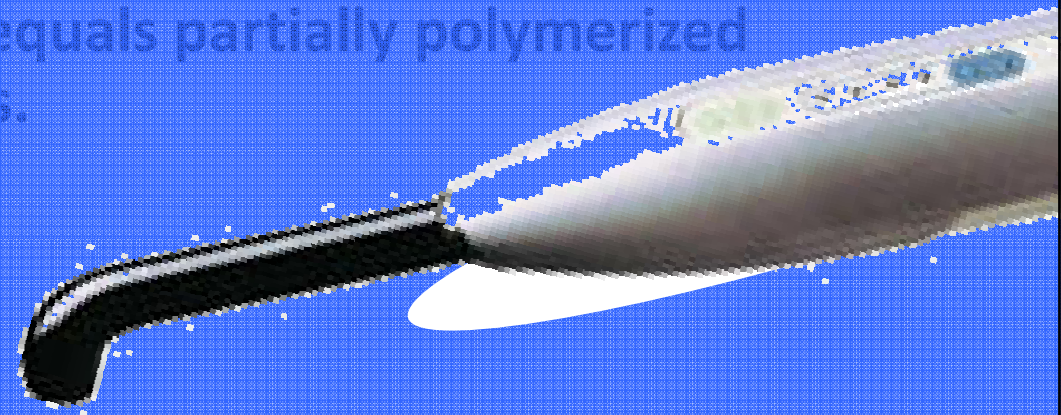
Air thin / Dry



Variables that affect quality of bonding

5) Light curing

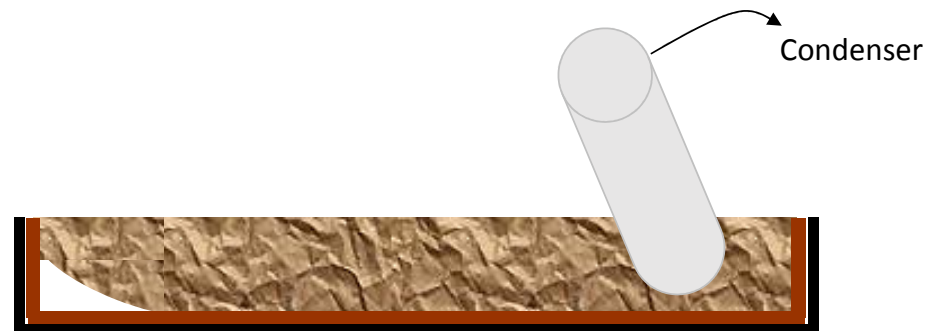
Too short or insufficient light cure equals partially polymerized resins.



Variables that affect quality of bonding

6) Composite Placement

Improper adaptation of the composite to the adhesive can create voids at the bonding interface.



Variables that affect quality of bonding

7) Contamination

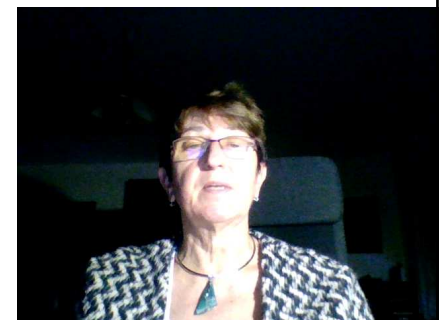
- **Blood**
- **Sulcular fluid**
- **Saliva**
- **etc...**



Variables that affect quality of bonding

8) Deteriorated product

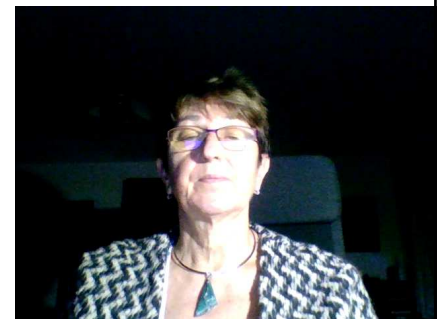
- Expired
- Volatilized





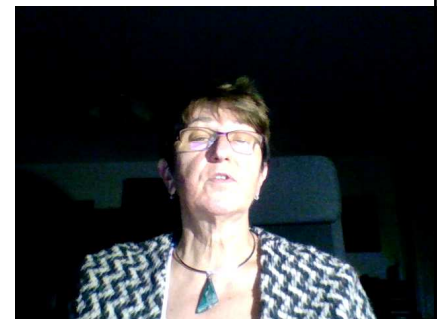
Indication of composite materials

- Filling of all classes:
- I., II. class: small to moderate restorations
- III. Class
- IV. Class
- V. Class
- *Other factors for consideration:*
- *Level of oral hygiene*
- *Occlusal loading*
- *Quality of hard dental tissues*



Other indication

- Splinting
- Postendo treatment (post and core)
- Cementation (special materials) – adhesive cementation
- Fissure sealing
- Venners – direct, indirect



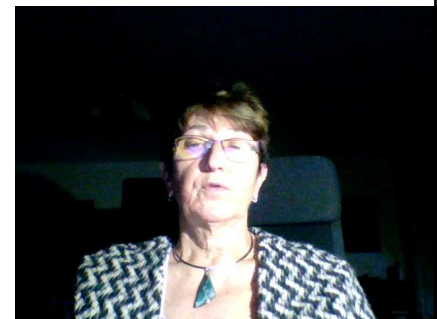
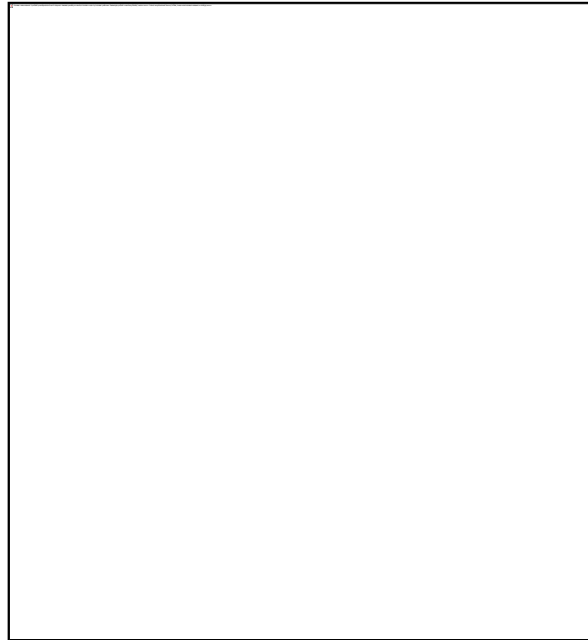
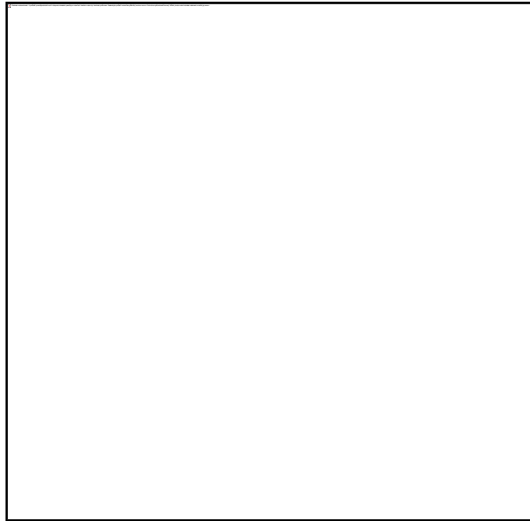
Contraindication of composite materials

- Bad level of oral hygiene
- Large cavities in posterior teeth (alternative is amalgam or inlay/onlay,
- Heavy occlusal stress (deep bite , bruxis)
- Cavities out of enamel (esp. cervical area)
- Social aspects



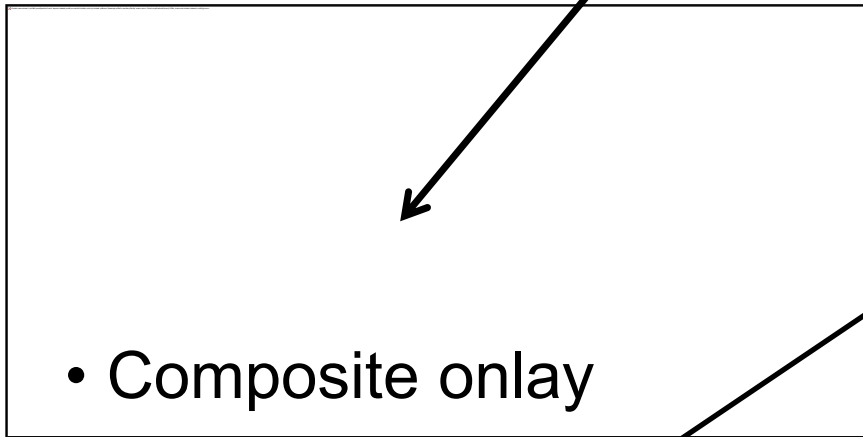


Postendo – post and core

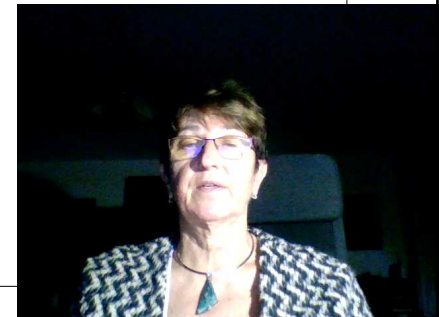
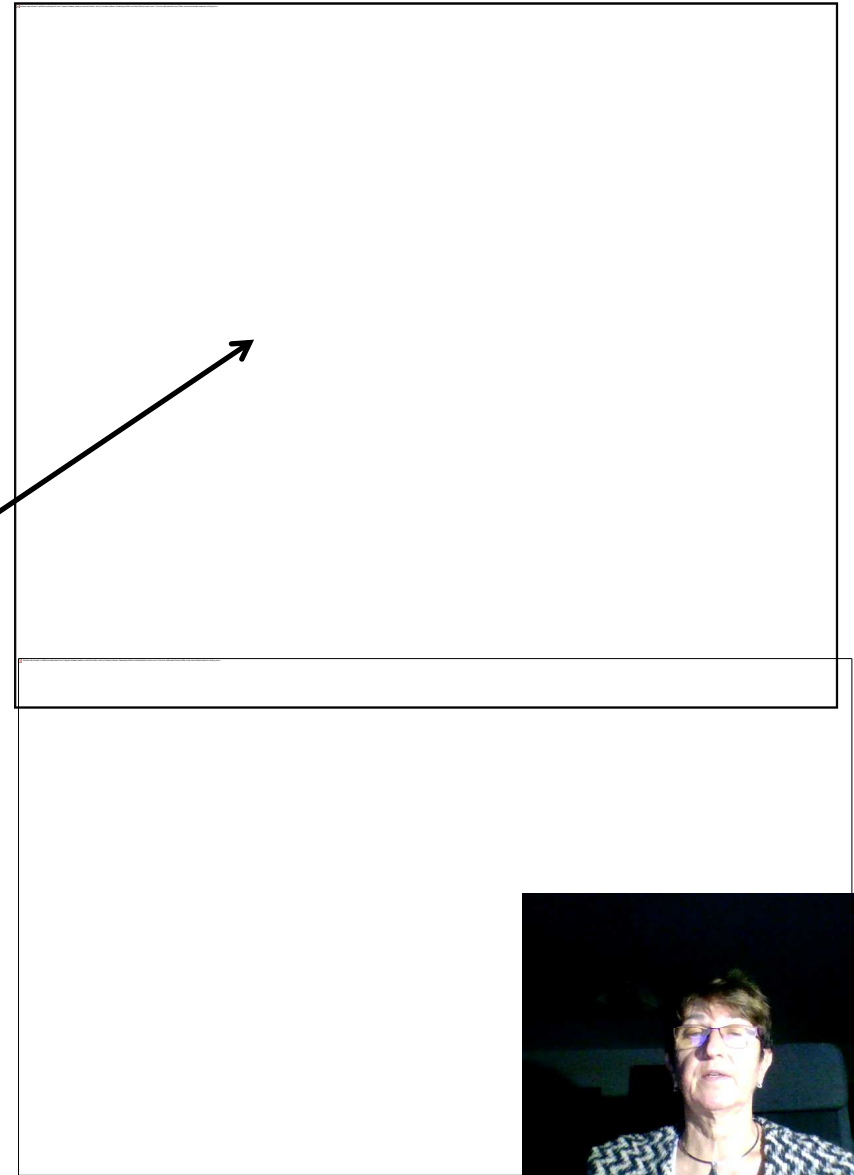


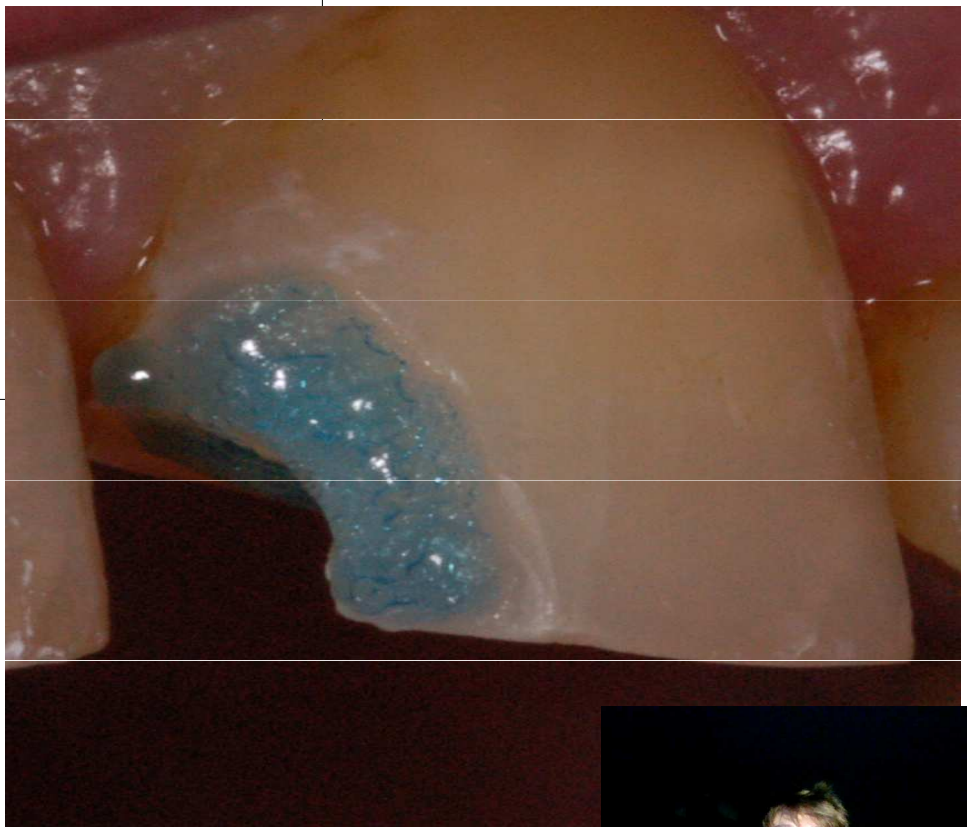
Postendo using flowable and onlay

- Flowable at the bottom

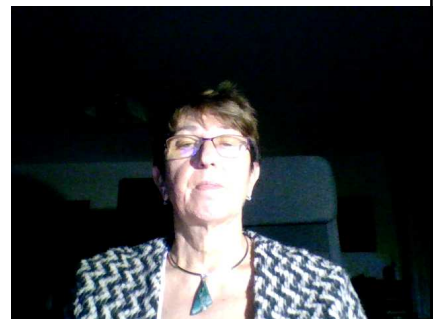


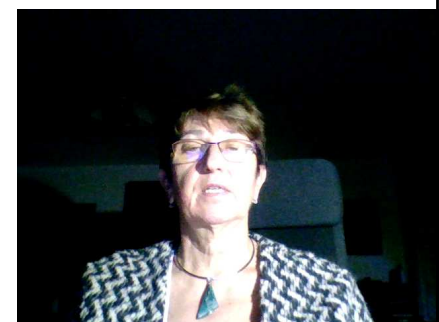
- Composite onlay
- Onlay after 8 years

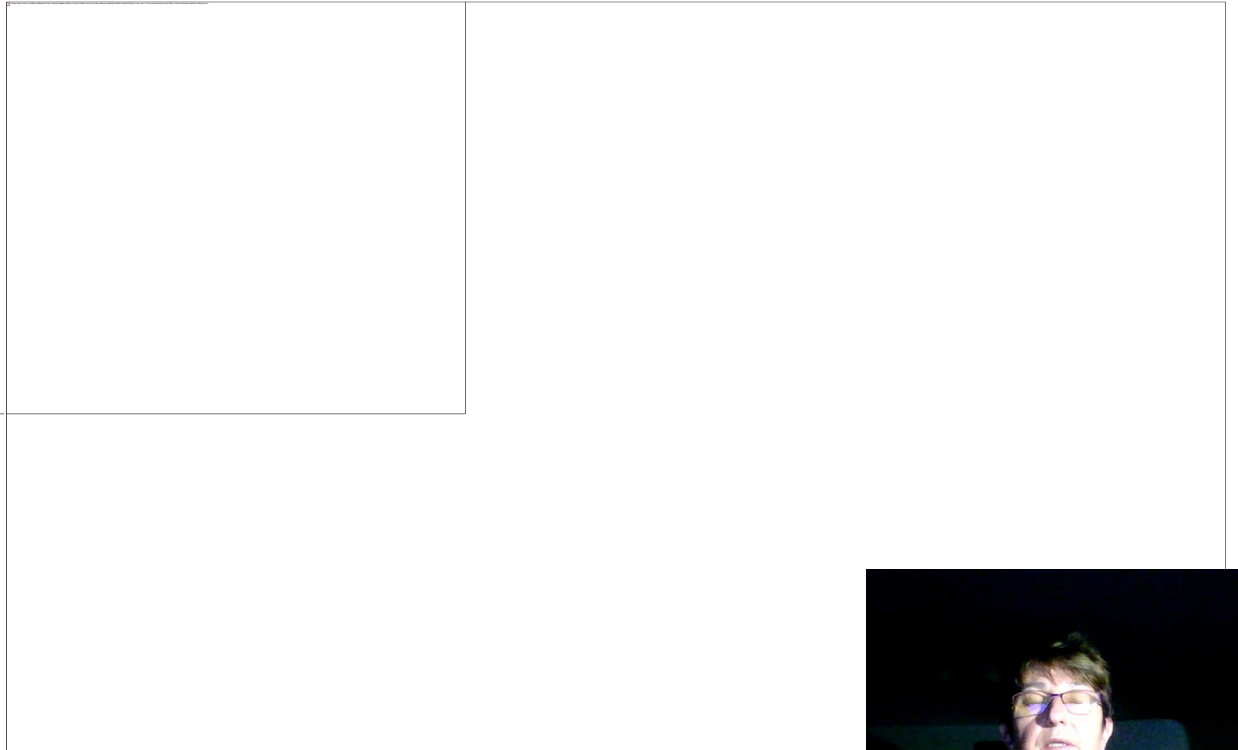
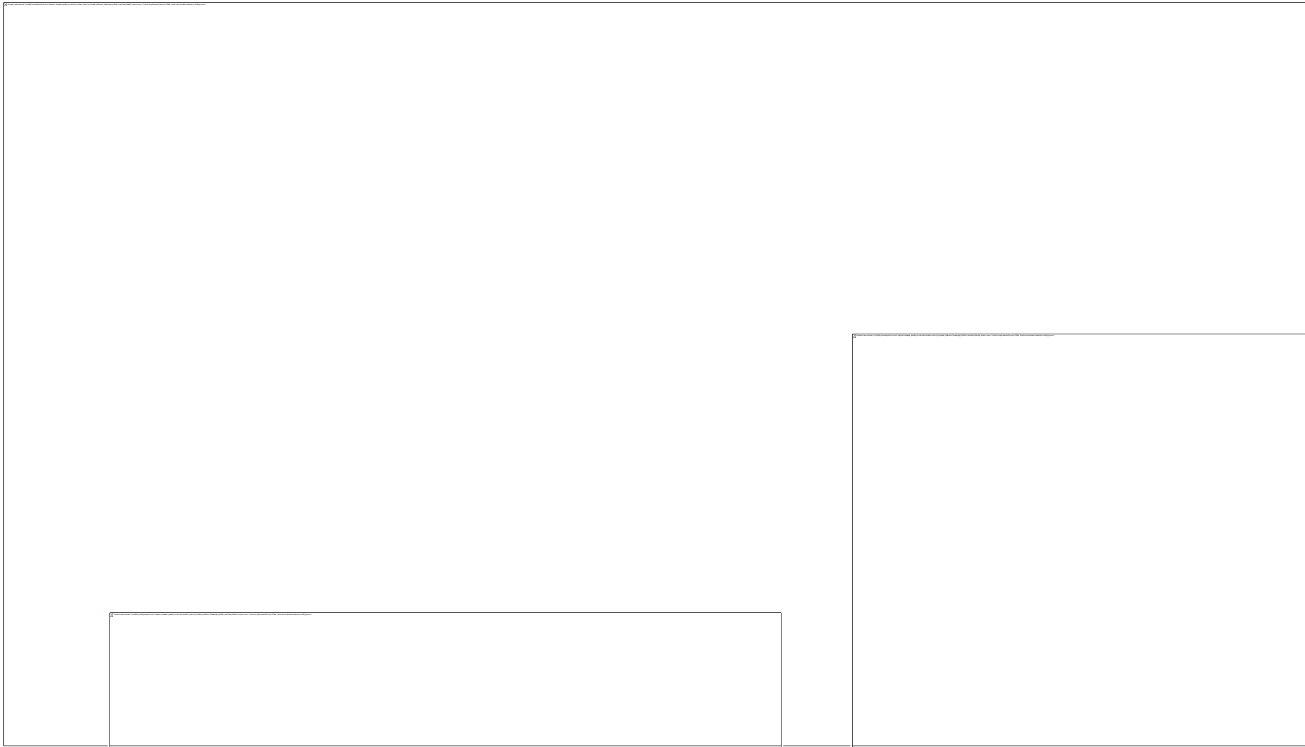


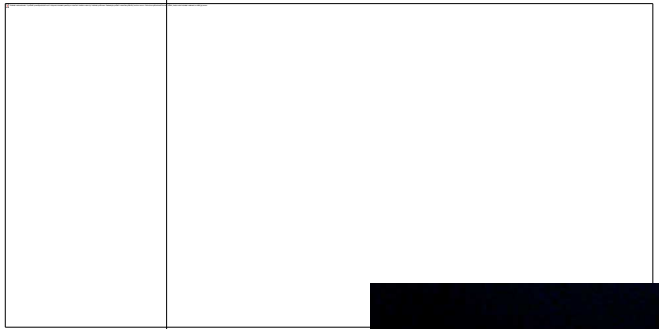
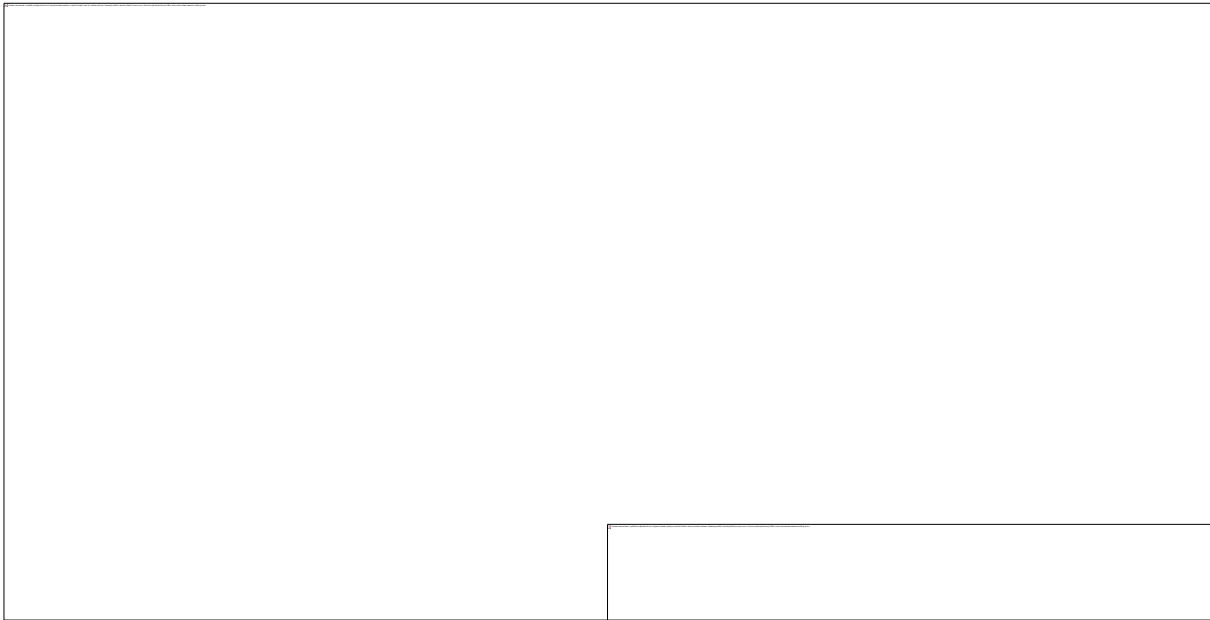












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