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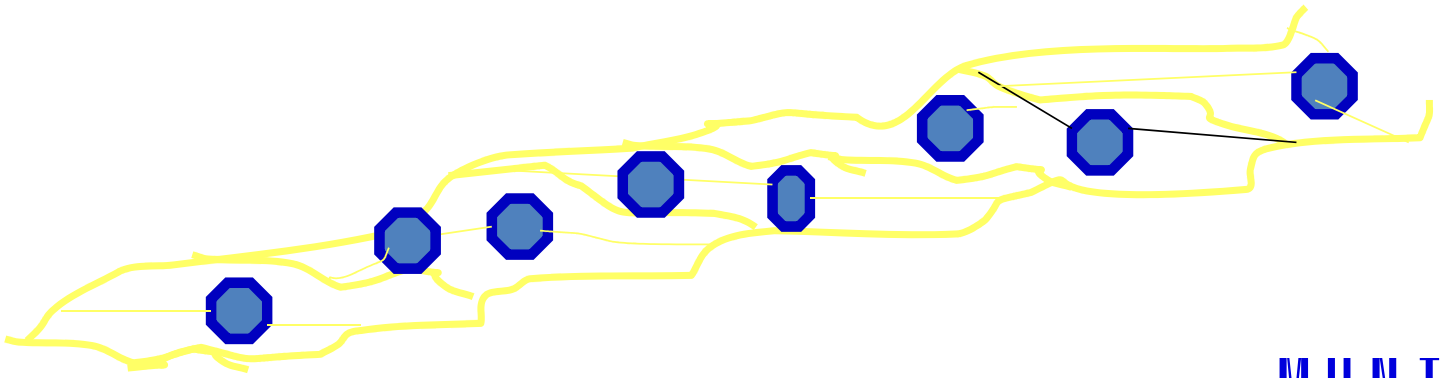
Restorative dentistry 3rd year
Lecture 2

L. Roubalíková

Composite materials

Chemically bonded mixture of organic matrix and inorganic fillers



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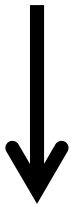
Coupling agent – binds organic matrix and the filler together



Homogenous distribution of the filler particles in the material

Excellent mechanical properties

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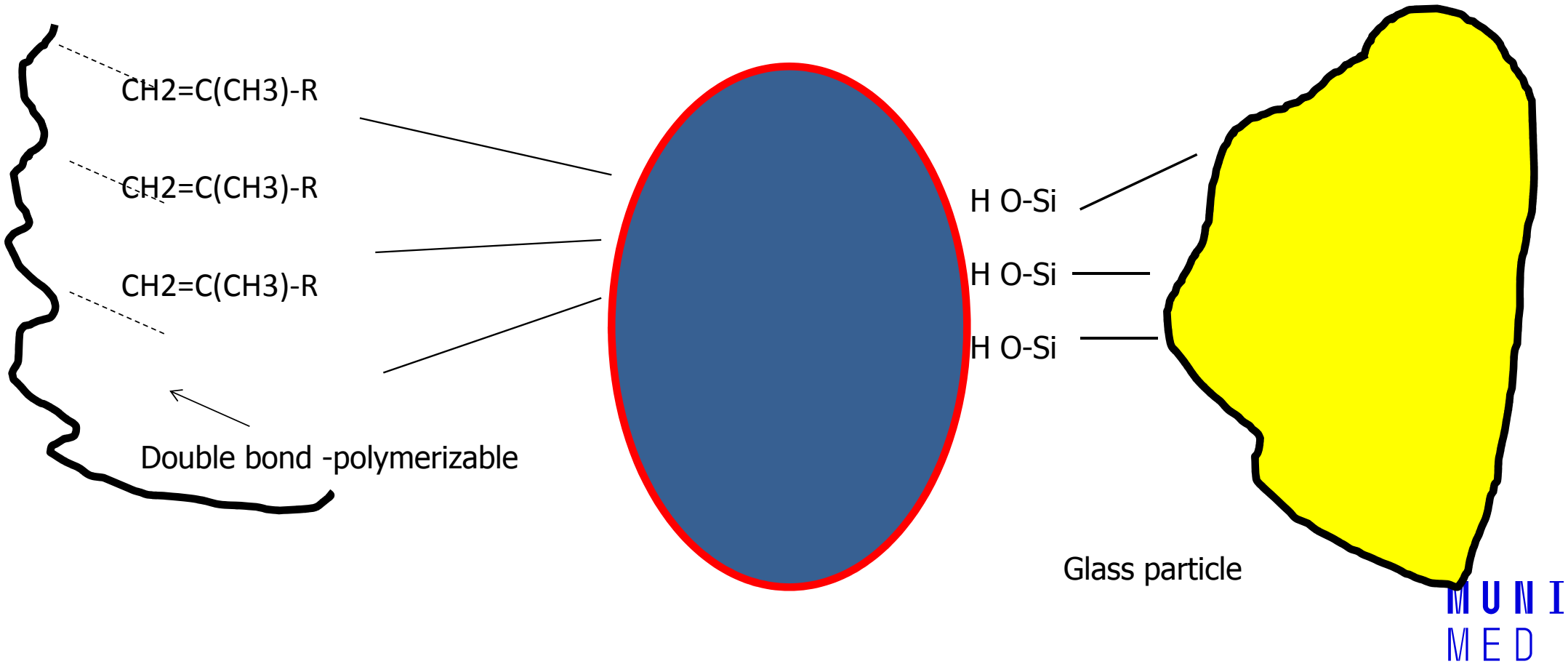
Binding of the coupling agents to glass particles



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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

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Filler – material

- Milled quartz
- Aluminimum silicate glass
- Silicium dioxide
- Prepolymer (composite material is polymerized with high pressure in fabrics, than milled – particles of the fiiler are made of cured composite)
- Complexes of microfiller (aglomerates) – e-g-. siliciumdioxide or zirconiumoxide

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Filler acc to the size of particles

- Macrofiller (size of particles µm ot tenth of µm)
- Mikroplnivo (hundredths od µm)
- Nanofiller (nm)
- Combination– hybrid

➢ Conventional (µm)

➢ Microhybrid (hundredths od µm, µm)

➢ Nanohybrid (hundredths od µm, µm, nm)

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Macrofiller

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

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Microfiller

- Silicium dioxide (pyrogenous)
- Particles hundreths µm

Less amount of filler due to big surface

Lower mechanical resistence, good polishability.

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Microfiller in complex particles

- Prepolymer
- Aglomerates

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

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Nanoparticles

- Particles 10 nm and less

Special technology, size, shape and binding to monomer

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Today

- Microhybrid or nanohybrid composites:

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

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Matrix

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

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

Dimethacrylates - mixture of materials with high and lower molecular weight

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Matrix - modification

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

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Coupling agent

- G -methacryloxypropyltrimetoxysilan (A 174)

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Other components

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

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Selfcuring composites

Activator Initiator

- Dibenzolyperoxide Tertiary amine

- Initiator Activator

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Light curing composites

- Initiator and sometimes also activator
  - Camphorchinon CQ
  - Phenylpropandion P
  - Trimetylbenzoylphosphi

Camphorchinon (CQ) - initiator

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

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Composite materials – basic characteristics

	Matrix	Filler
Compressive strength	↓	↑
Elasticity	↑	↓
Polymerization shrinkage	↑	↓
Polymerization stress	↓	↑
Water sorption	↓	↑

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Classification of composite filling materials

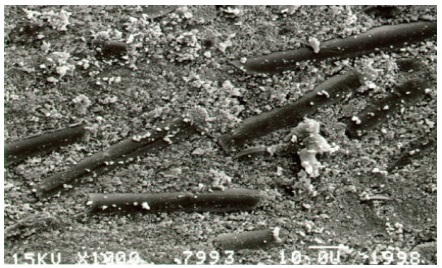
- Size of the filler particles

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

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History

- Fusayama 1979

Adhesion to dentin

Yoshida. Nakabaiashi

Van Meerbeck

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35% - 37% phosphoric acid
silica particles
blue dye

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2
1
Prime
OptiBond
Self-Etch Adhesive
Simplicity
1
Simplicity
2
G-BOND
5mL
0086
AdheSE
1
AdheSE
2
3M ESPE
Adper
Scotchbond
Multi-Purpose
Adhesive
7543
Single Bond
Adhesive

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Adhesion

- Mechanical adhesion

- Specific adhesion
- Intermolecular forces
- Chemical binding

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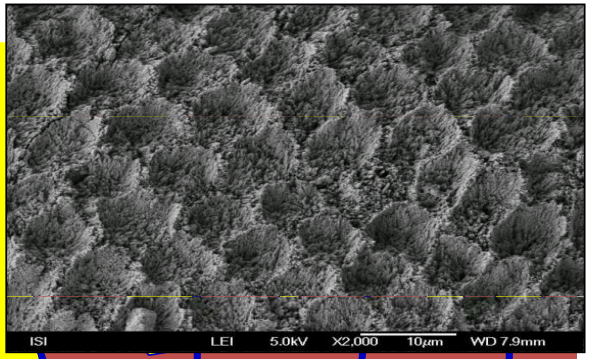
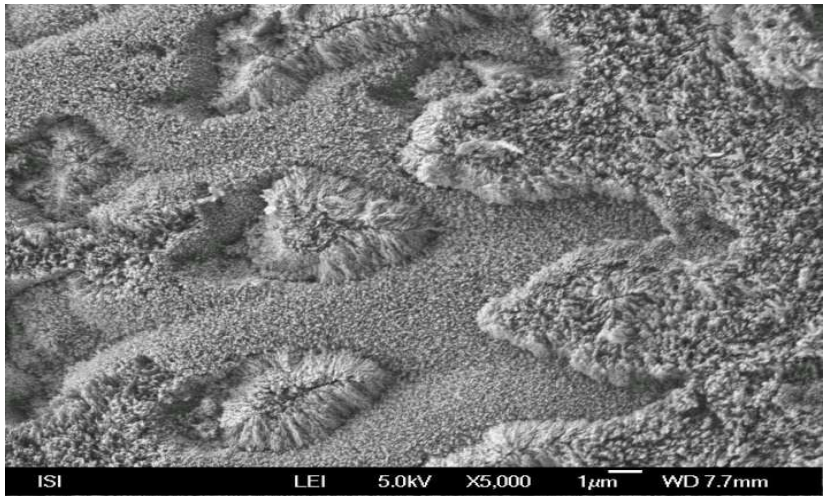
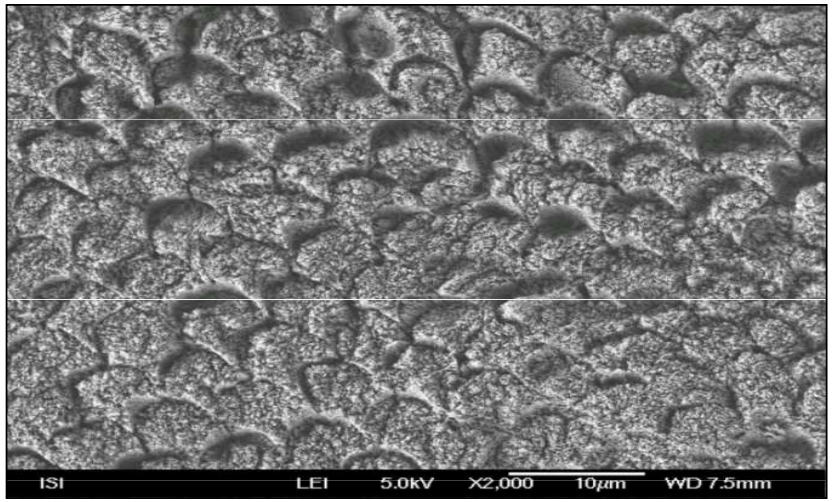
Enamel



Acid on aprismatic enamel

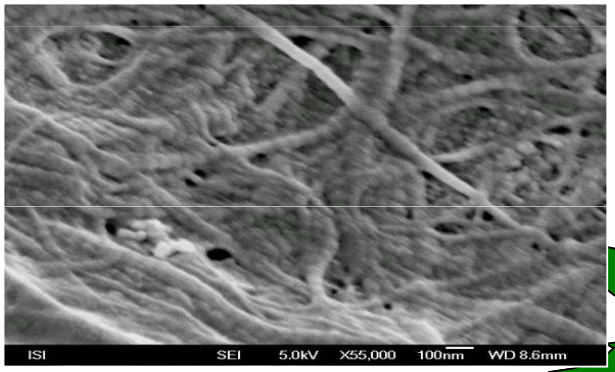


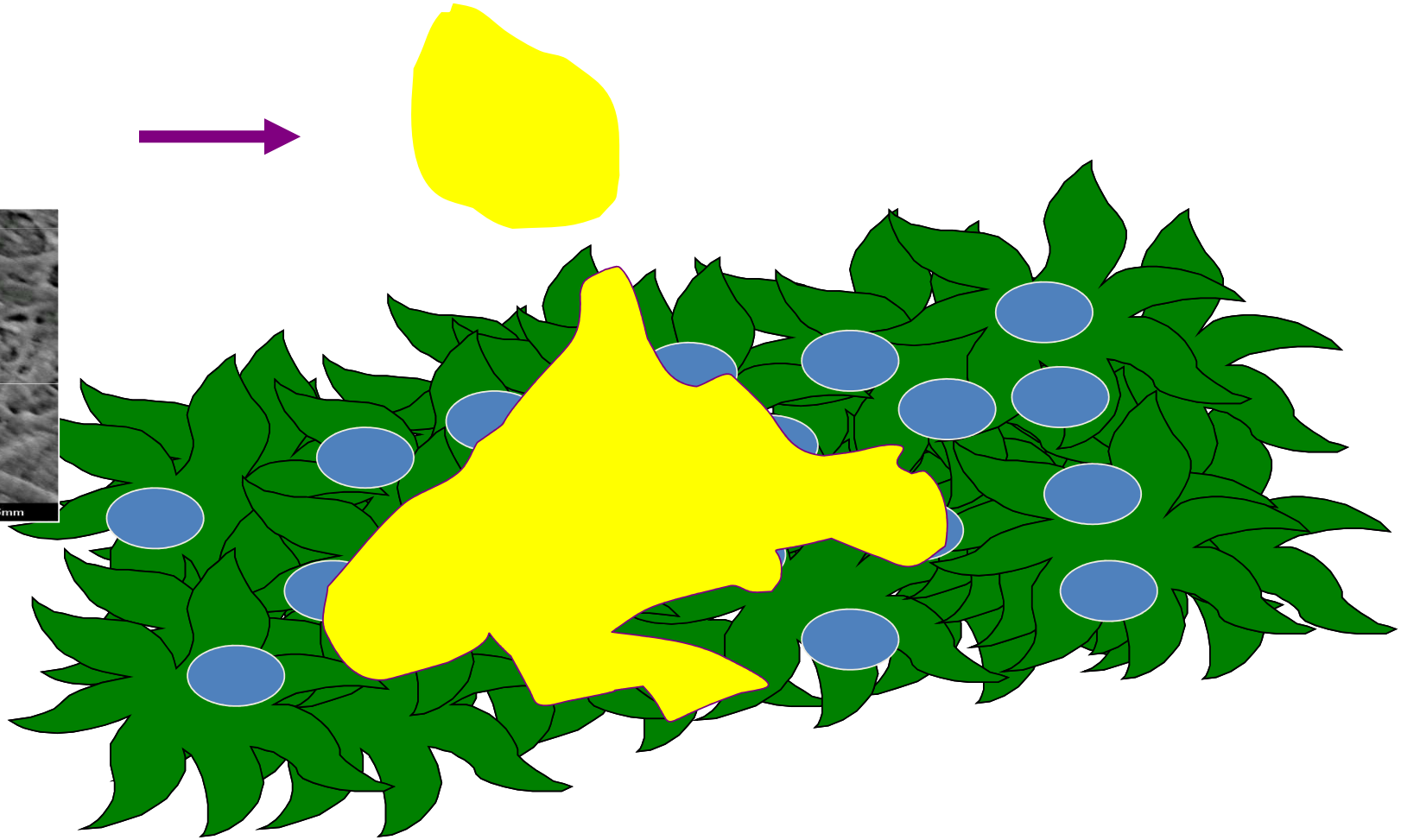
Acid on prismatic enamel



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?

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Dentin – special composition

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

Composite is hydrophobic, we need hydrofilic substance

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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 necesssary for dentin.

The hydrophillic 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.

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Adhesive systems contain resin monomers

Primer:

- 4-META
- HEMA
- TEGMA
- PENTA P
- 5-NMSA

Bis-GMA

Bond: Bis-GMA ot other dimetacrylates. Hydrophpobic.

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Dissolving agents

- Aceton
- Alcohol
- Water
- Water/alcohol

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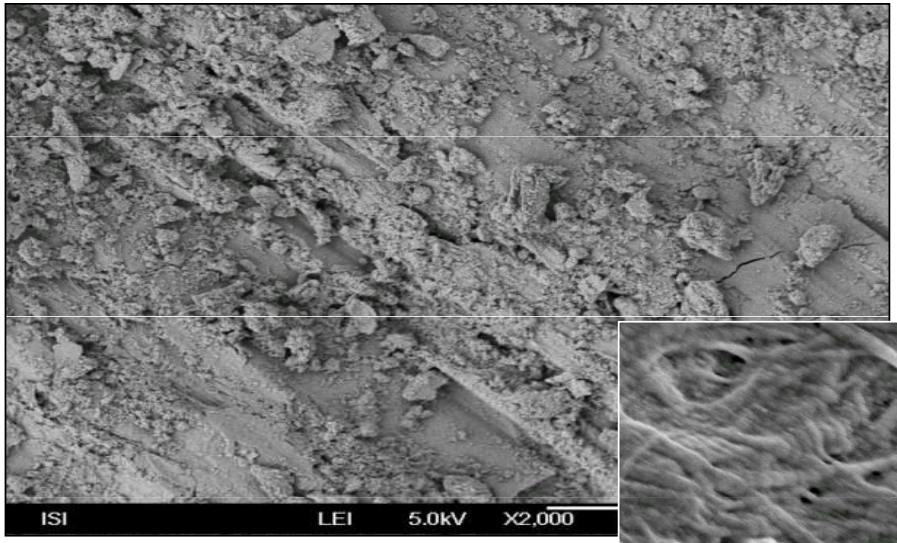
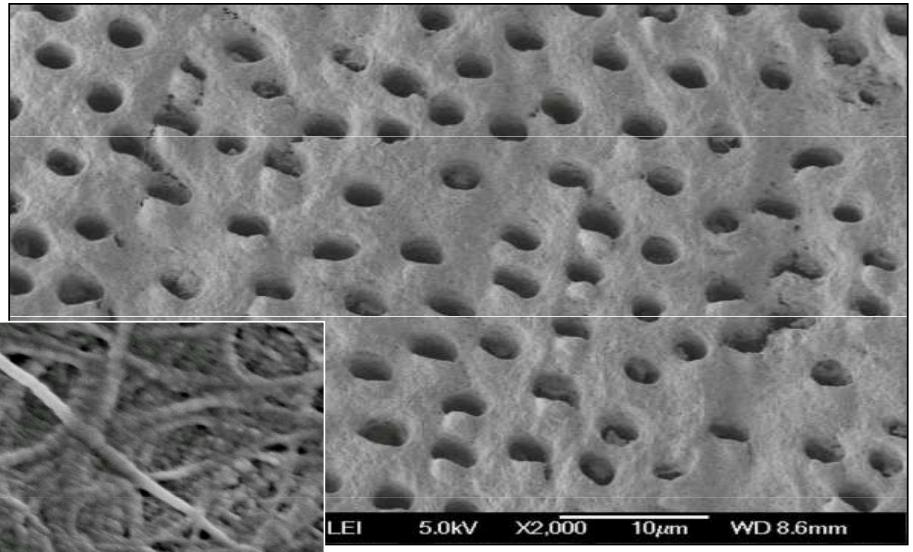
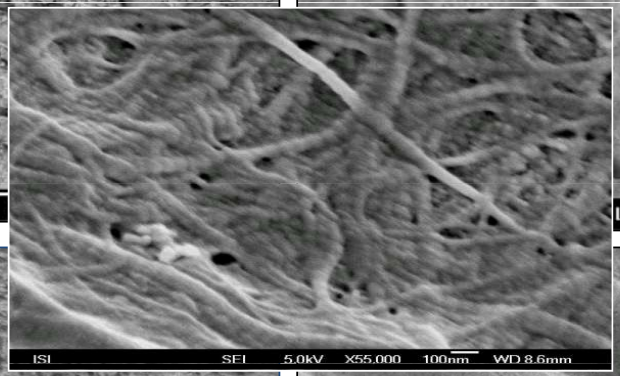
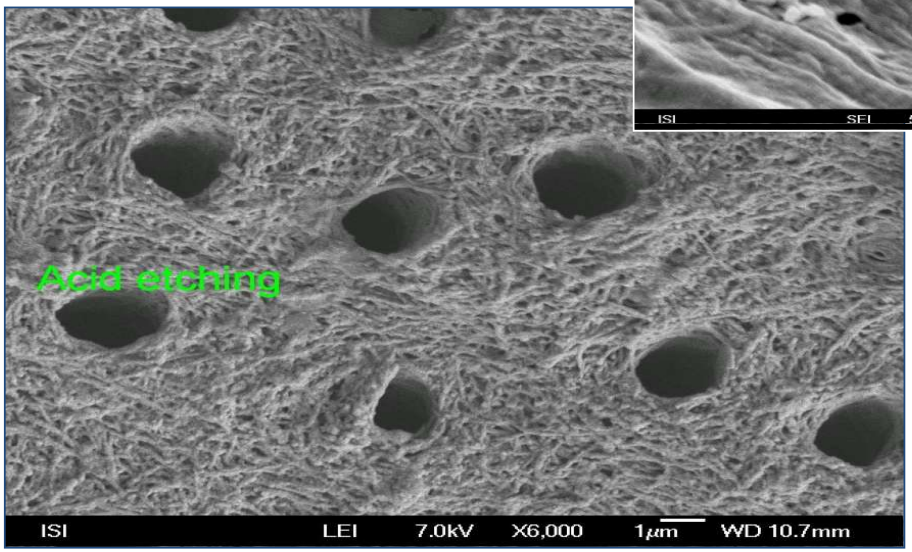
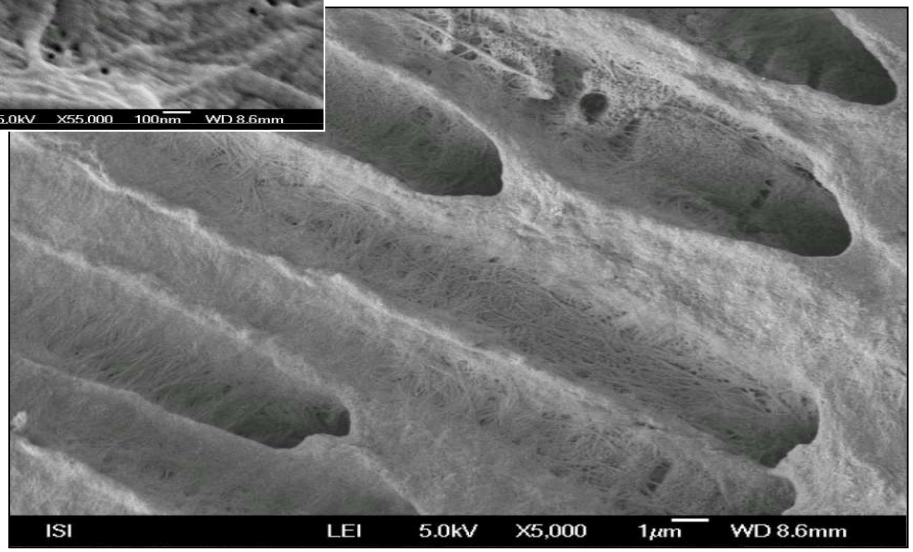

ISI LEI 5.0kV X2,000


LEI 5.0kV X2,000 10μm WD 8.6mm


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


Acid etching
ISI LEI 7.0kV X6,000 1μm WD 10.7mm


ISI LEI 5.0kV X5,000 1μm WD 8.6mm

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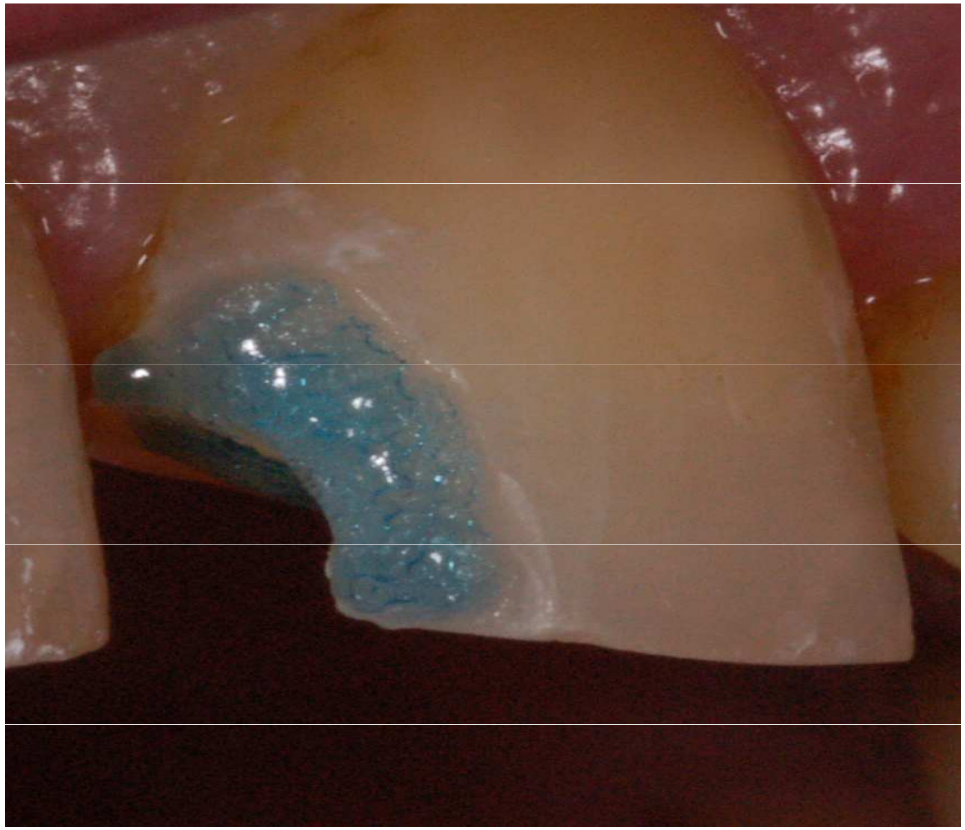
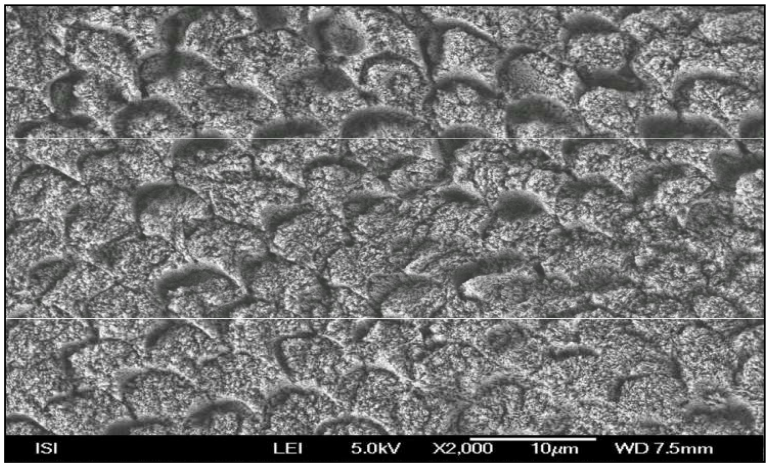
Clinically oriented classification of the adhesive systems acc to number of steps

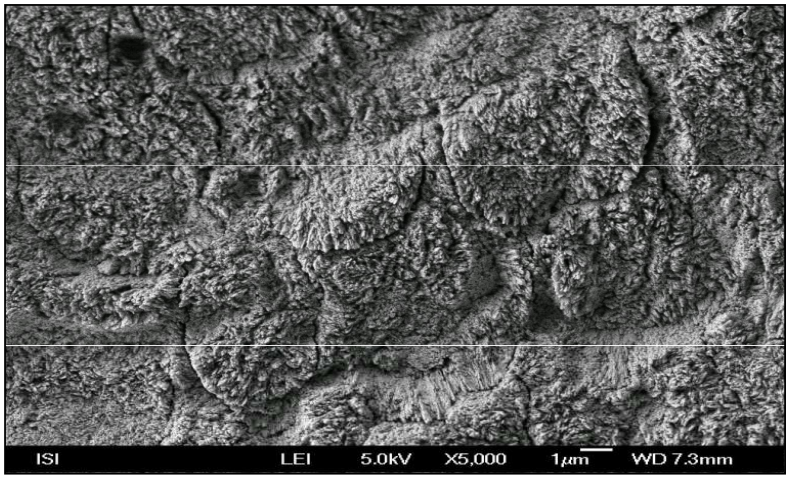
Acid etching	**Rinsing**	**Priming**	**Bonding**
Acod etchin	**Rinsing**	**Priming a bonding**	
Selfetching priming			**Bonding**
Selfetching bonding)			



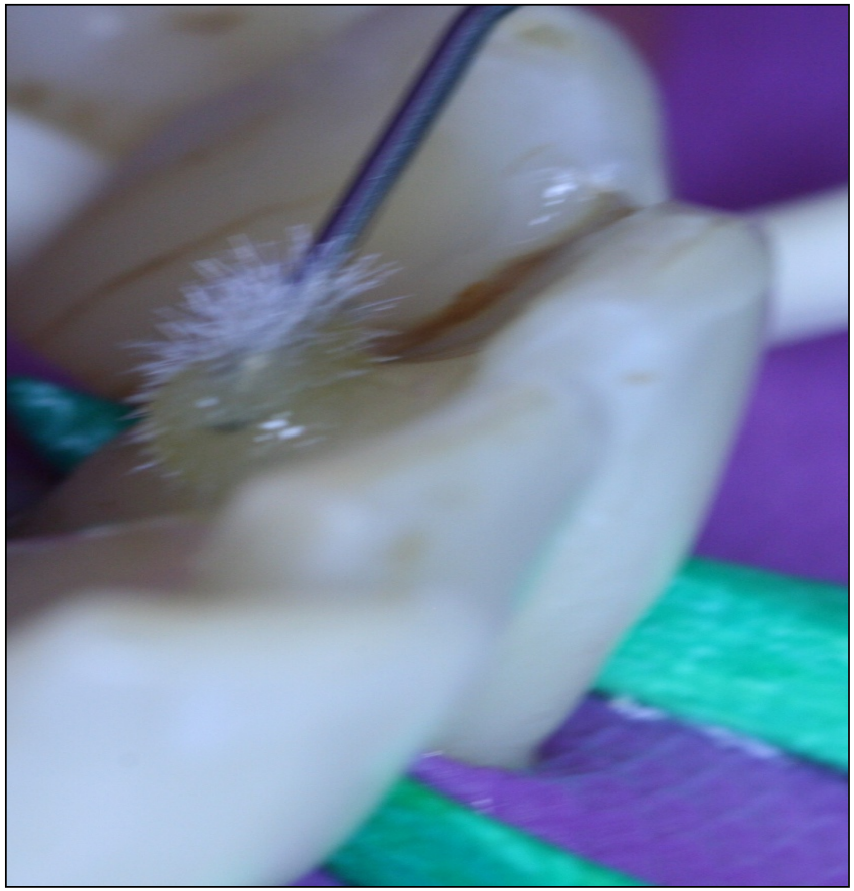
Srelfetching bonding agents



TE – Total etch,
ERA



SE – Self etching
SEA



Two steps selfetching agents

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

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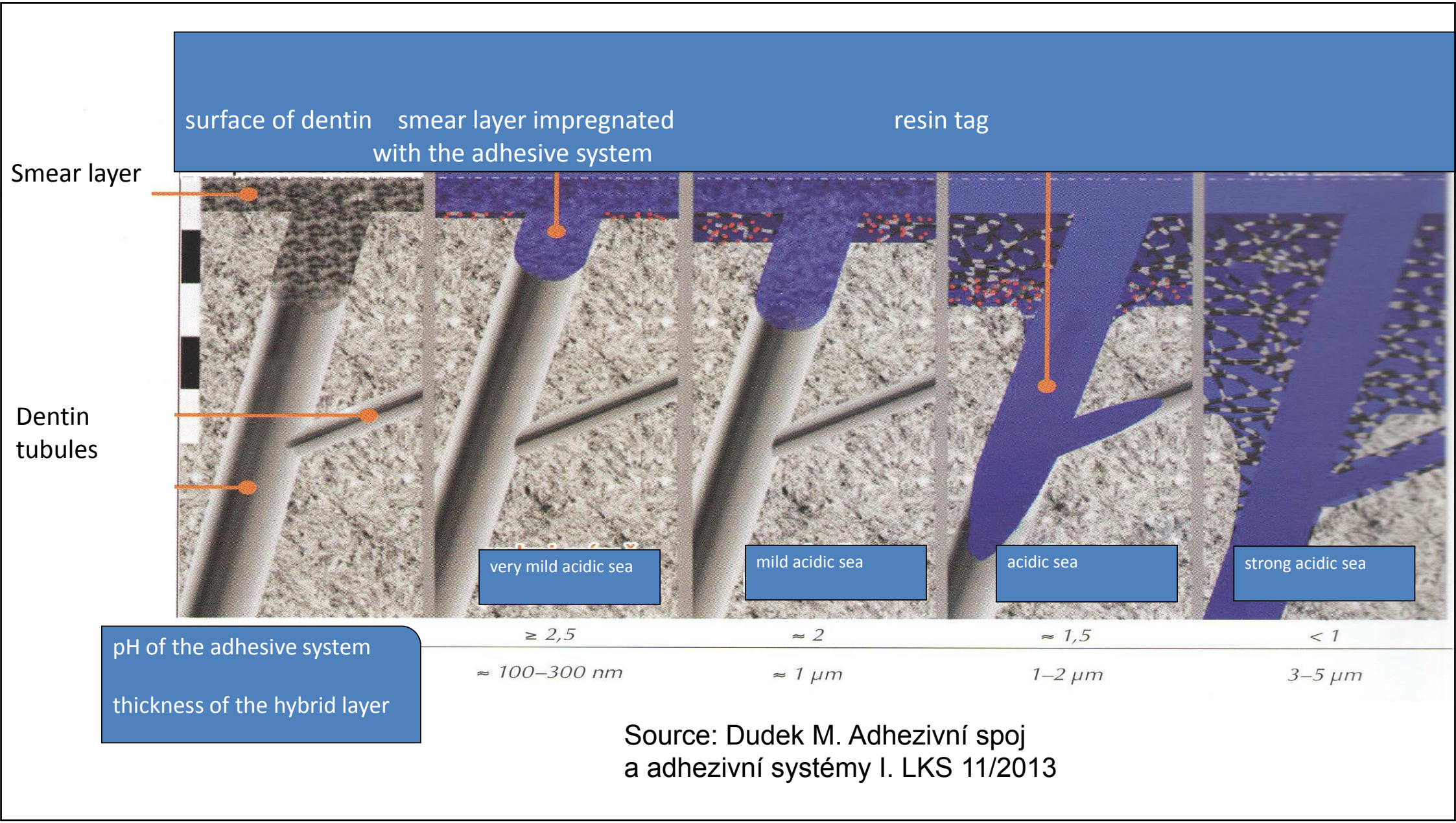
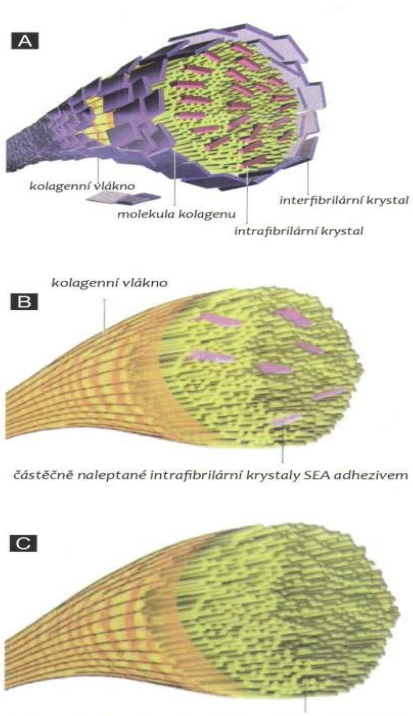
One step selfetching agents

- More vulnerable bonding, risk of hydrolysis



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



Colagen fibers with interfibrilar and
Instrafibrilar 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 metaloproteinasis)

  - Strong mineral acid id dangereous for good long term bonding
  - Clorhexidin for one minute can stabilize collagen

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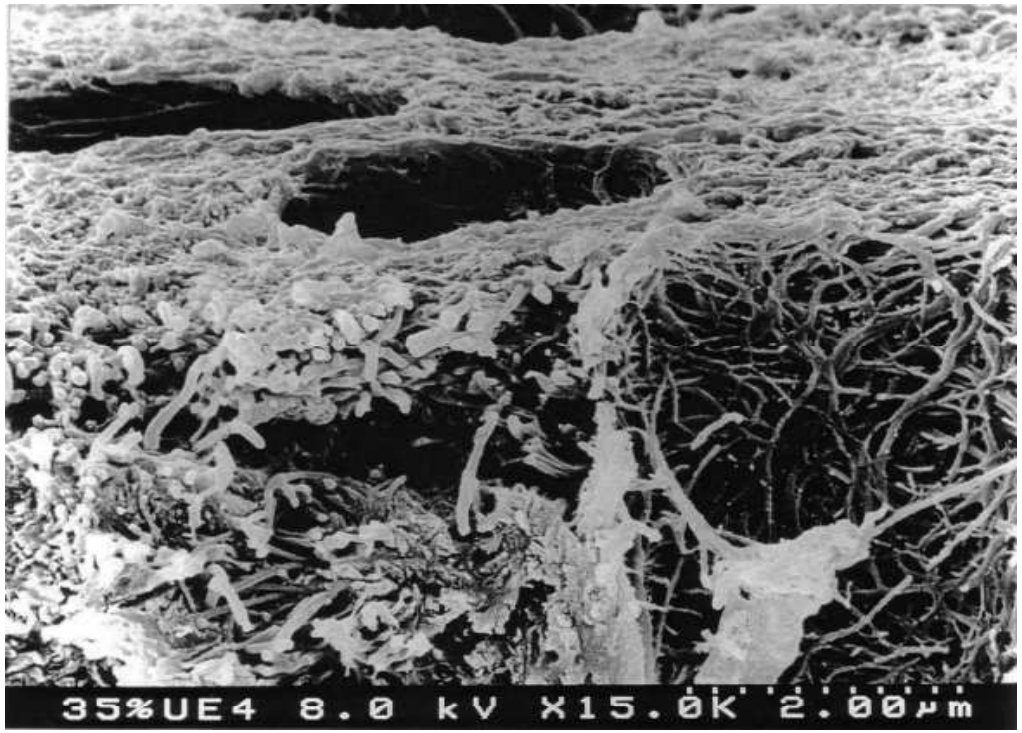
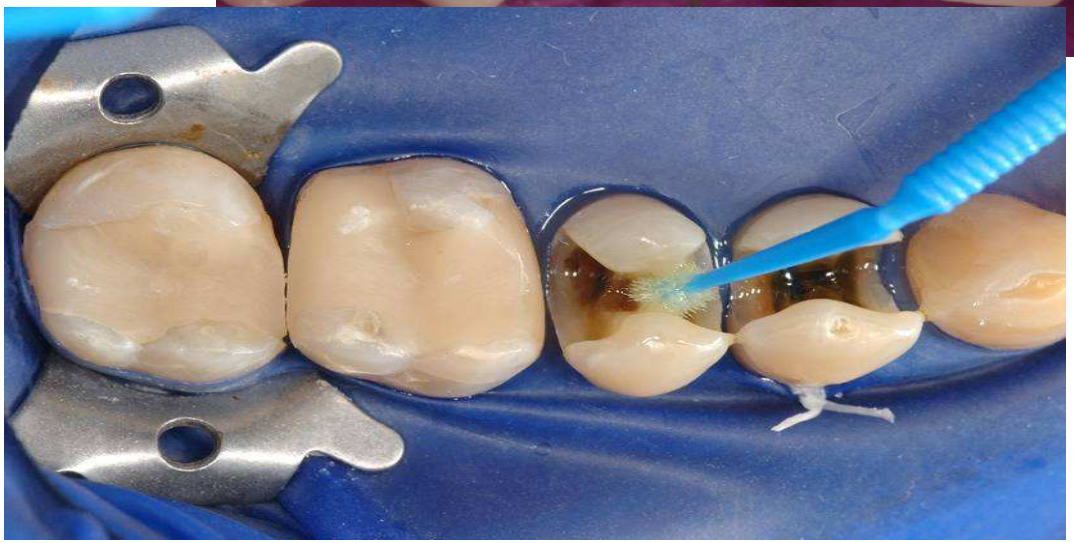
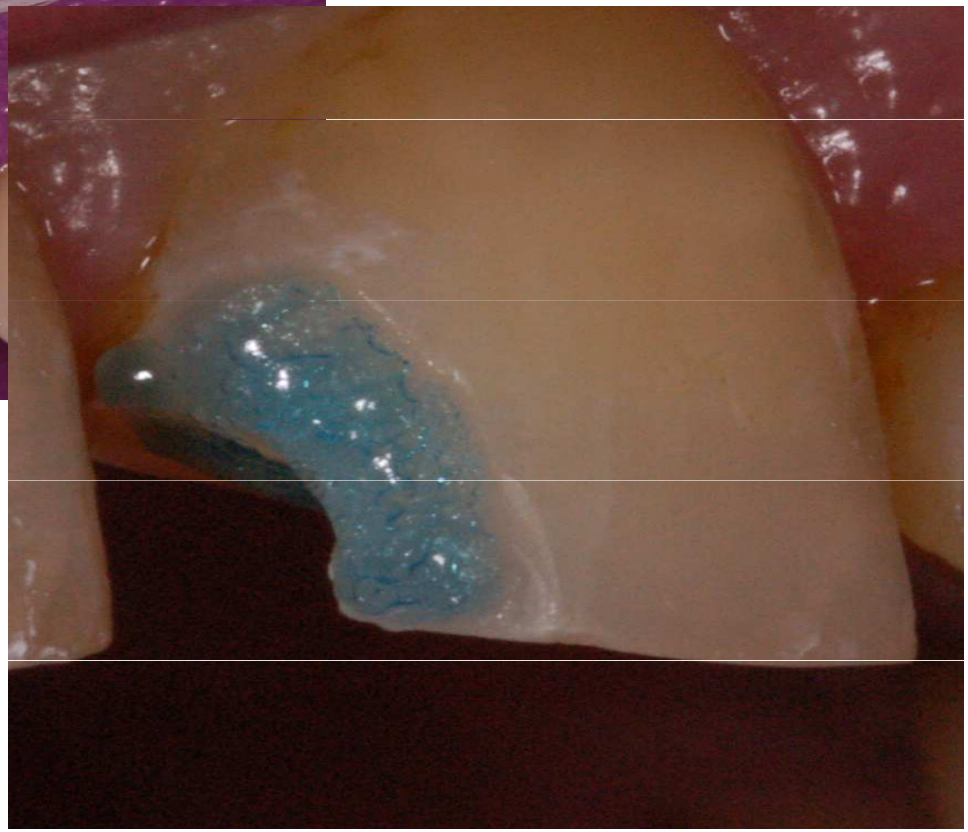


Enzymatic degradation of collagen





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.)

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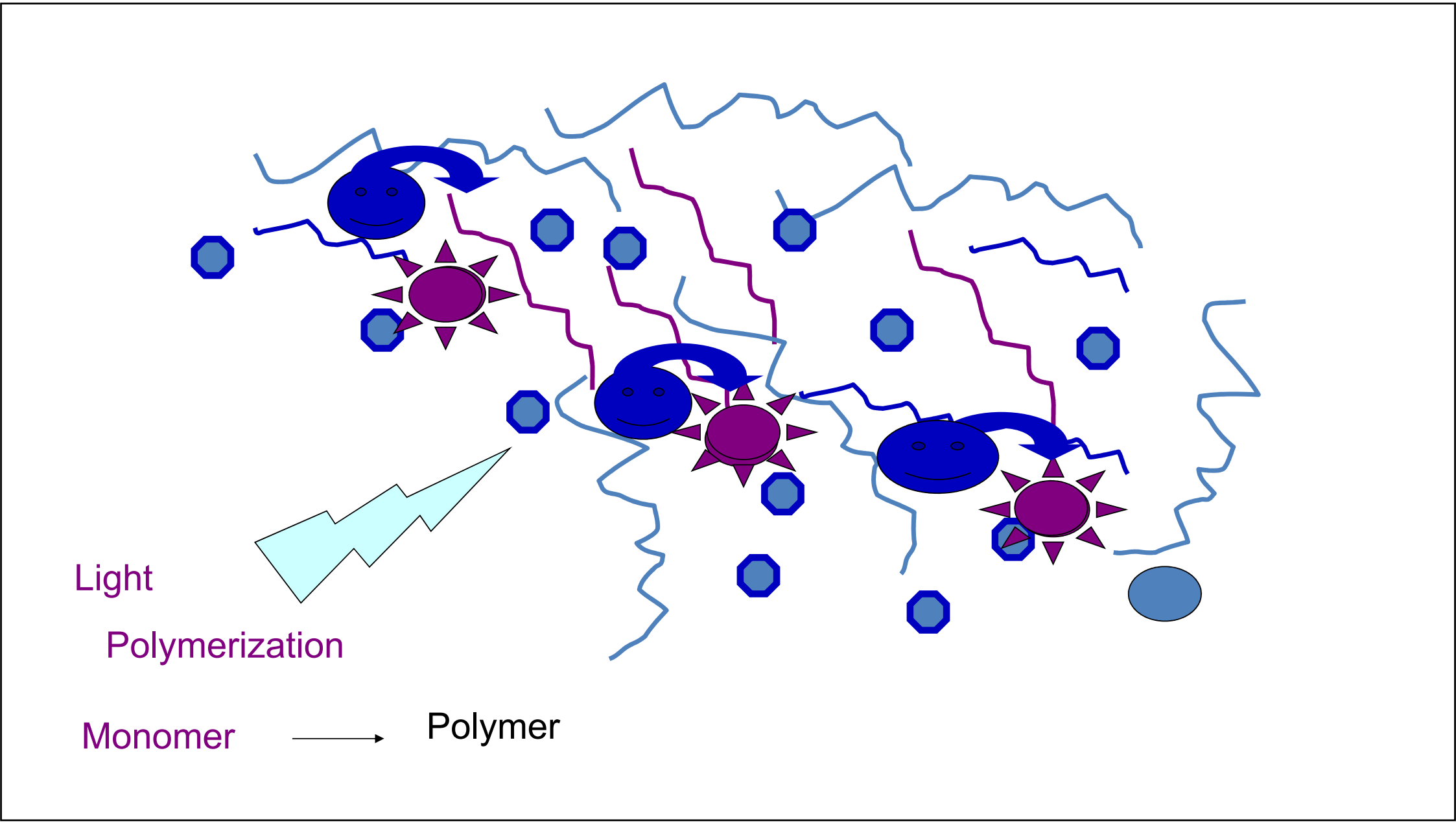
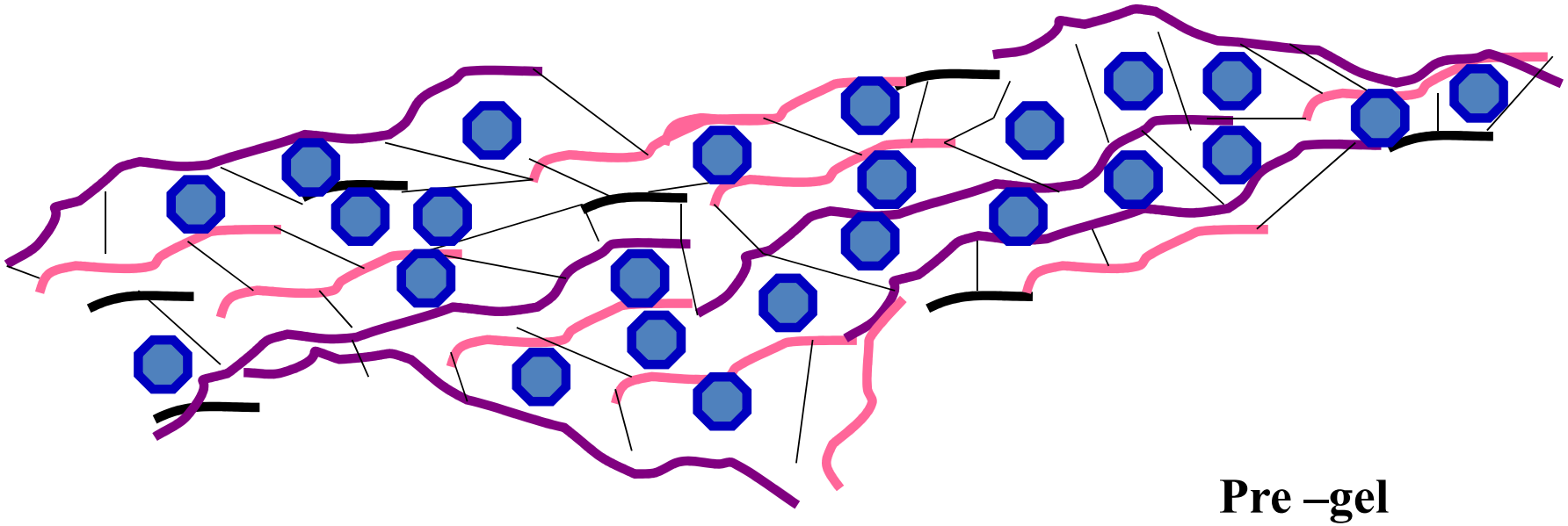

Light
Polymerization
Monomer
Polymer

Pre gel phase should be long – soft start !!!!



Pre –gel
Gel
Post -gel

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Three phases

Phases

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

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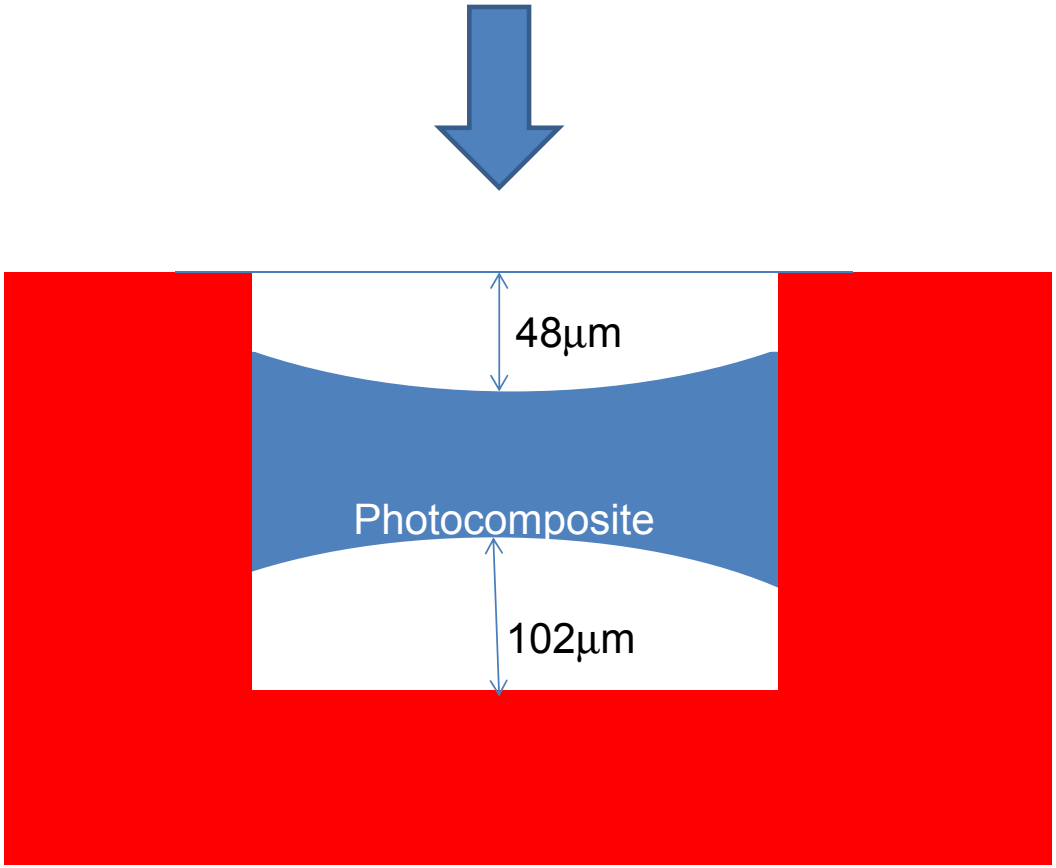
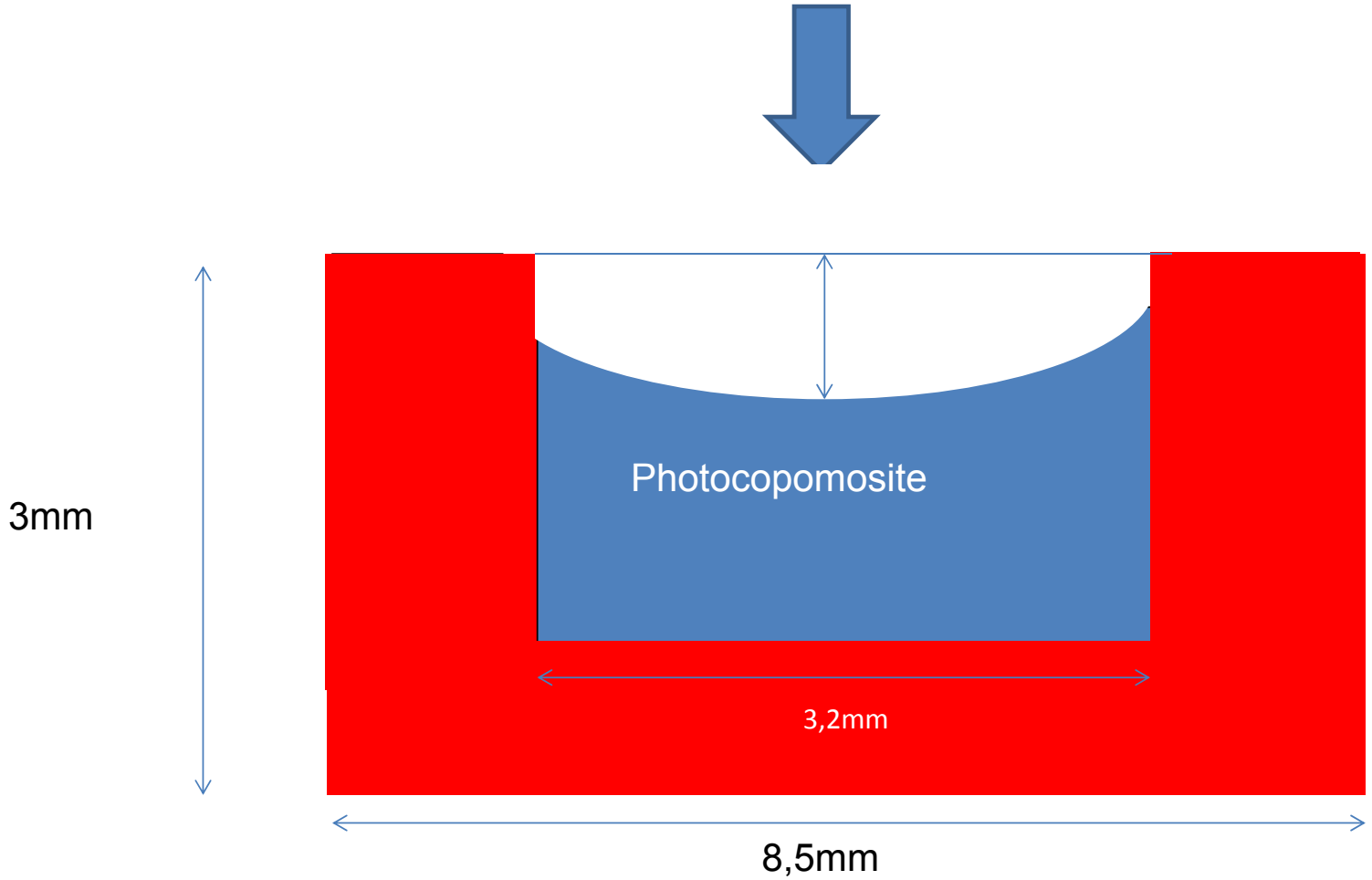
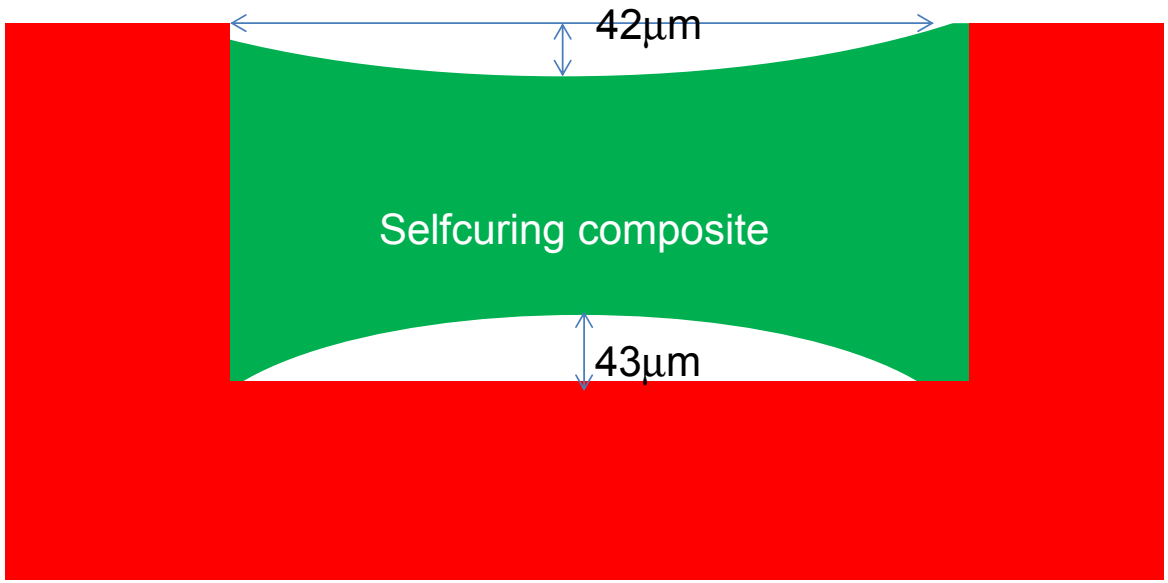

48µm
Photocomposite
102µm


Photocopomosite
3mm
3,2mm
8,5mm


42µm
Selfcuring composite
43µm

Polymerization stress depends on

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

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Polymerization stress depends on

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

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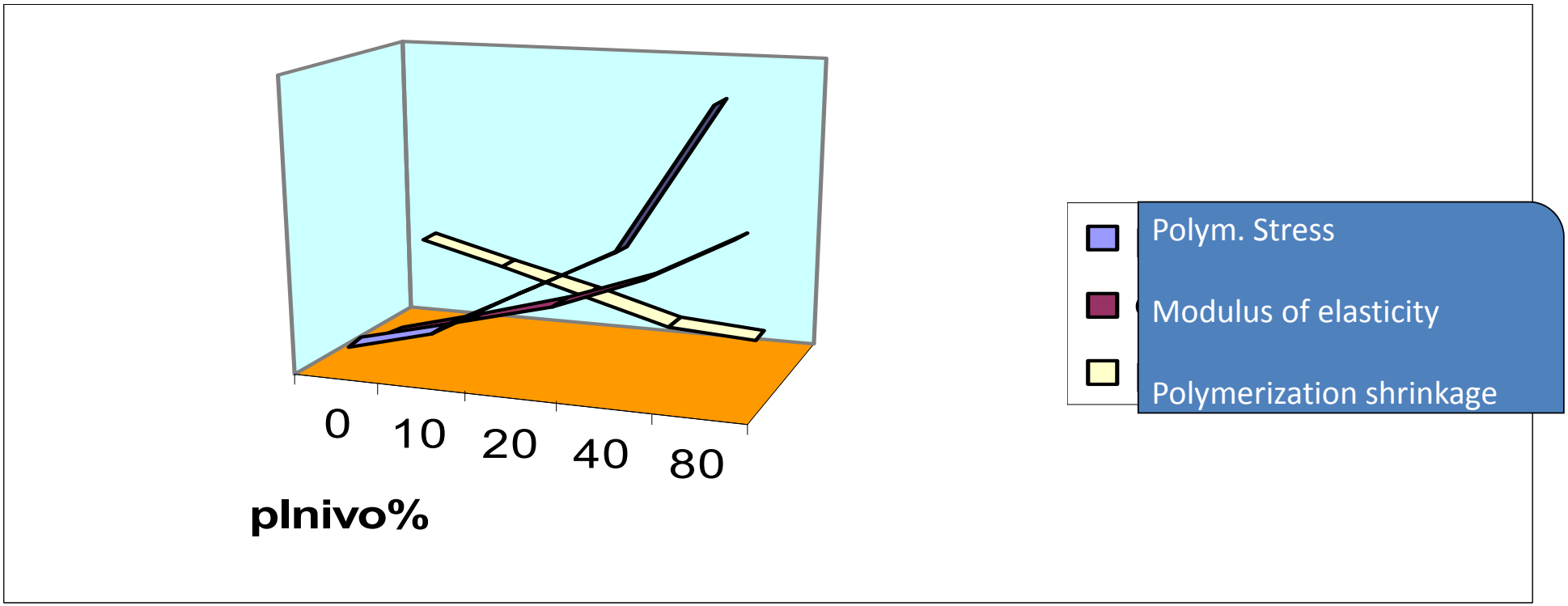
High content of filler increases the modulus of elasticity
High modulus of elasticity increases the polymerization stress
High content of filler decreases the polymerization shrinkage



Polymerization stress depends on

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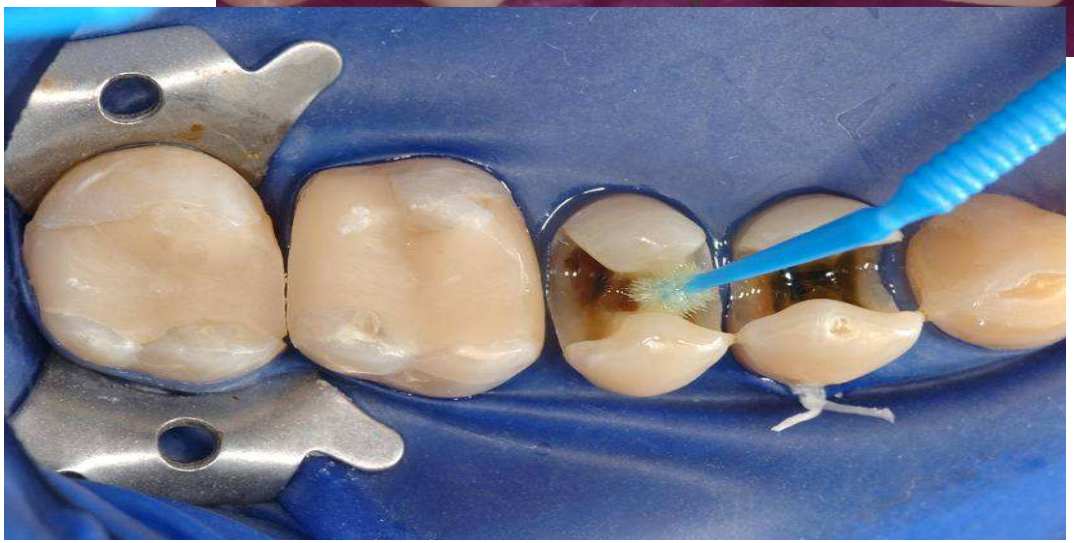

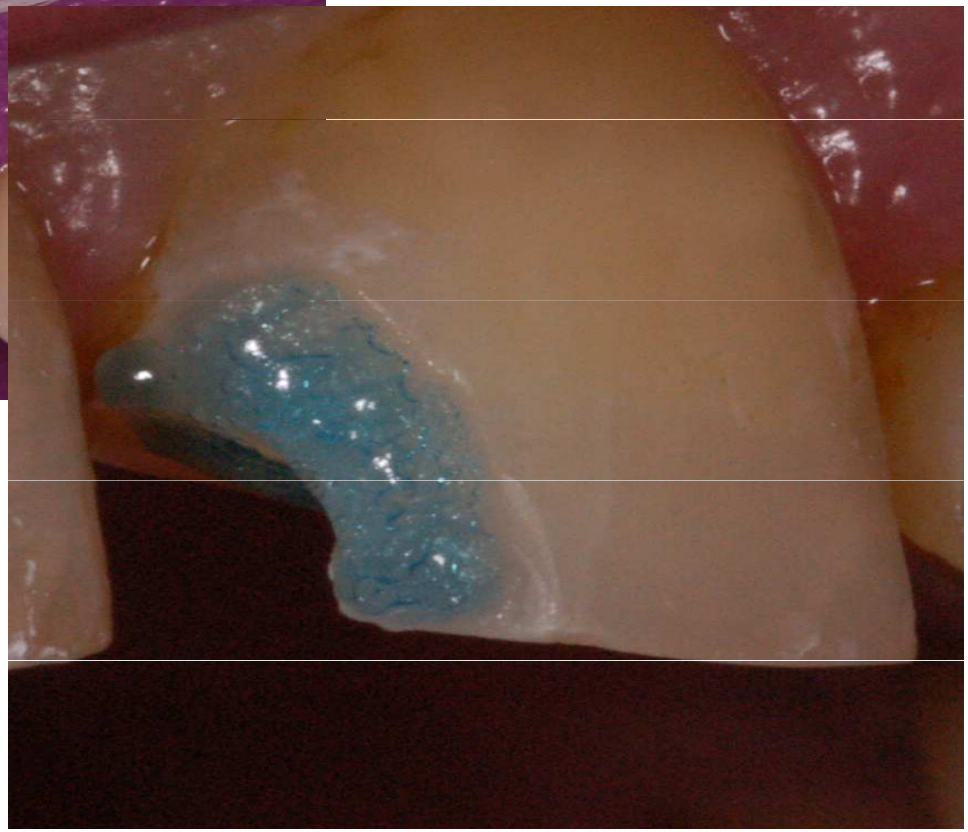

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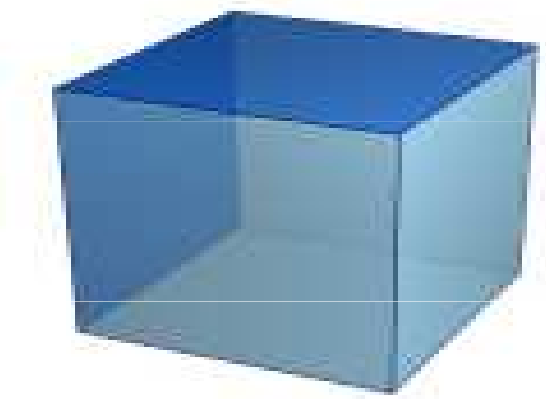

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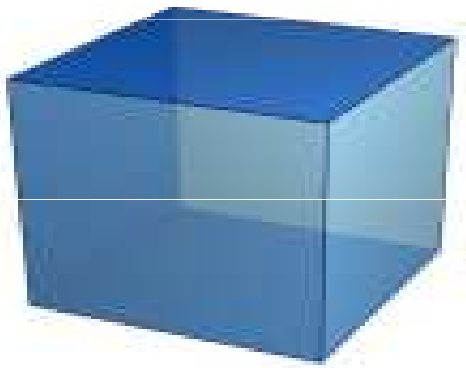

1

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

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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

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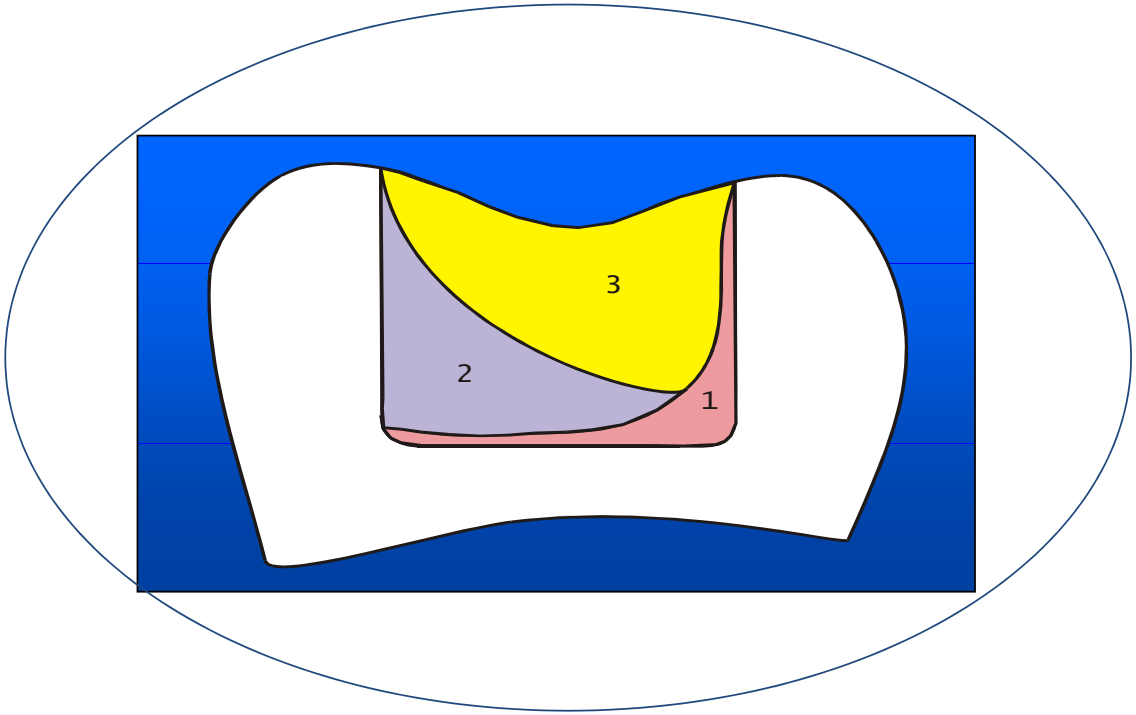
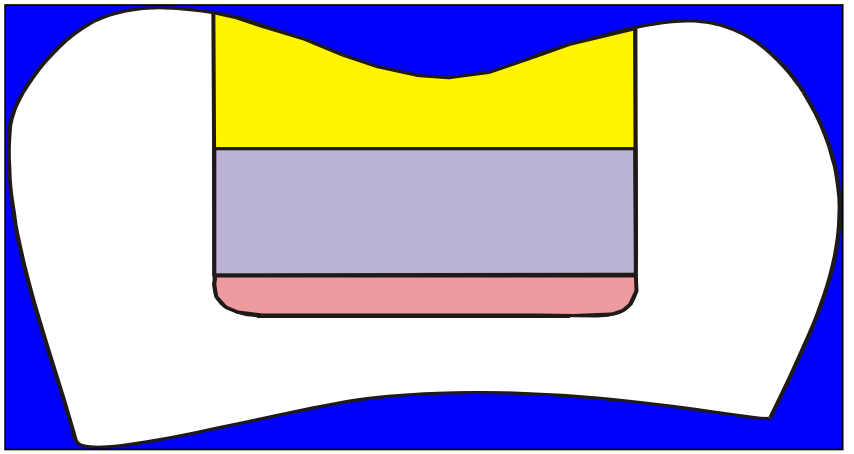
Placement of the material

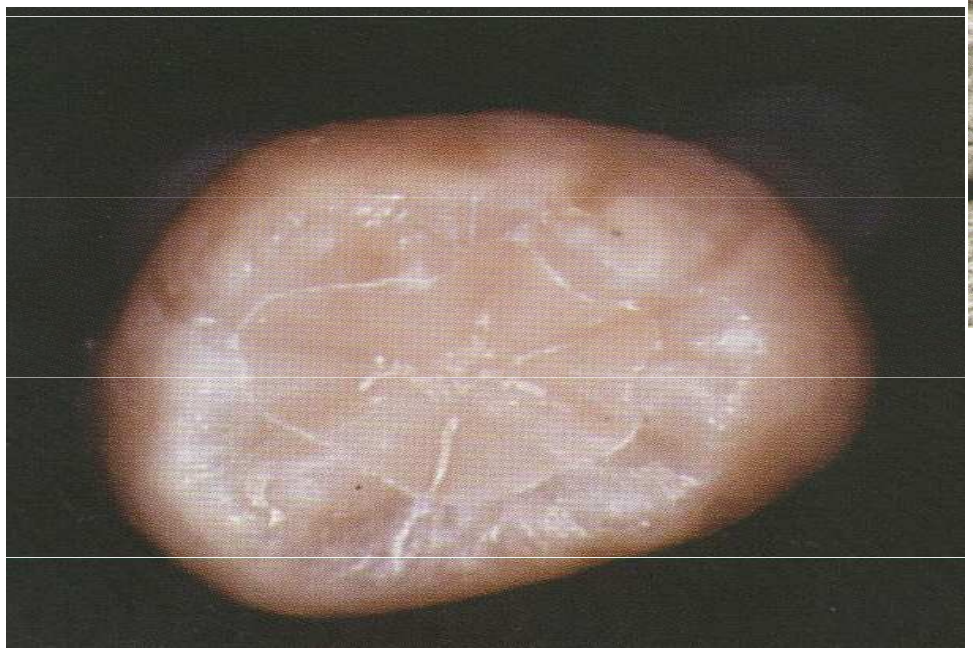


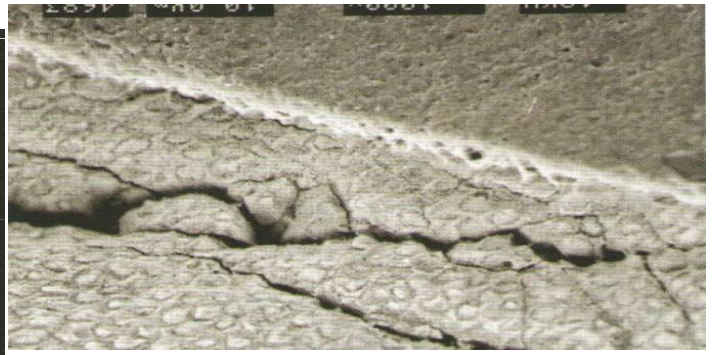


Placement of the material

- 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

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Polymerization stress depends on

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

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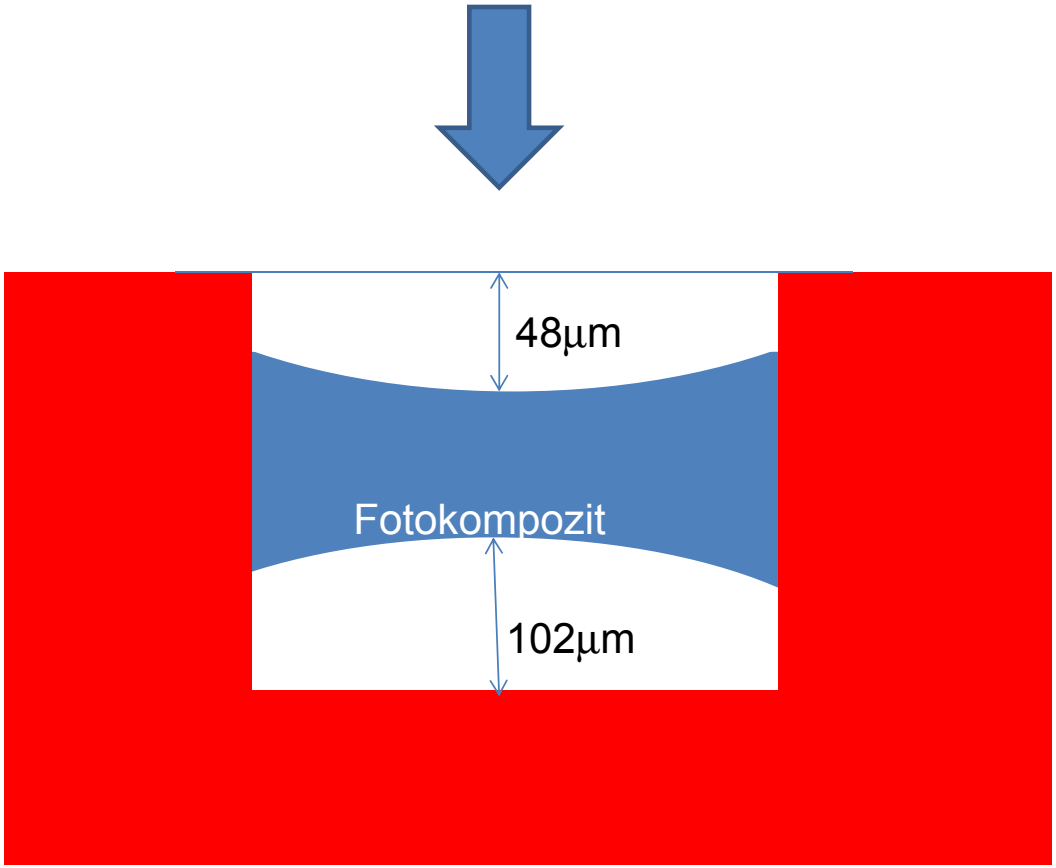
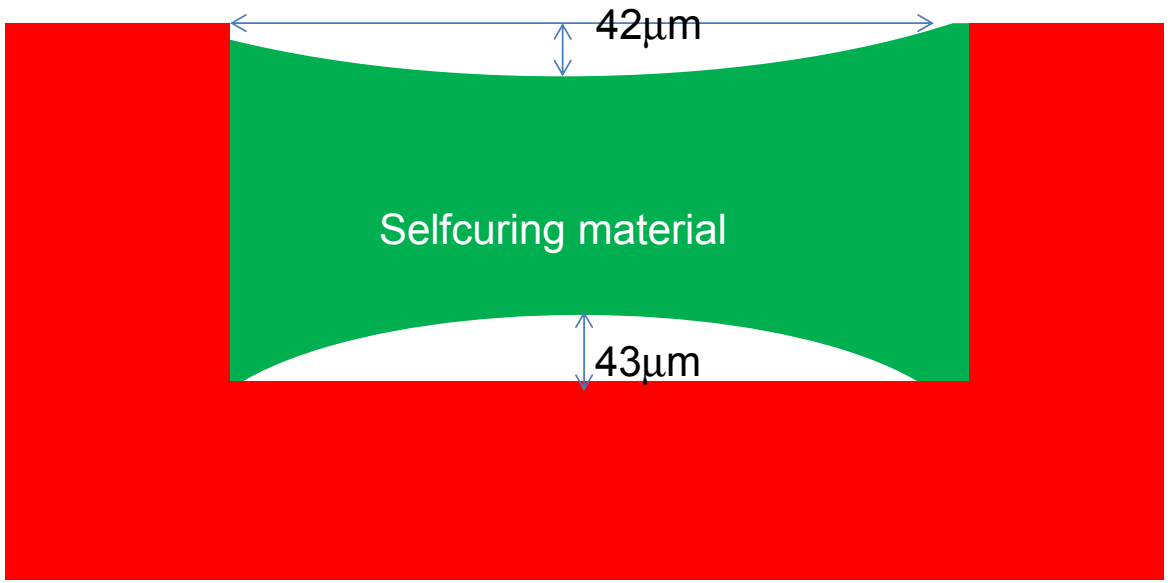

48µm
Fotokompozit
102µm


42µm
Selfcuring material
43µm

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)

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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.)

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Cpontemporary possibilities polymerization

- Quarz halogen units (halogen lamp)
- Plasma units
- LED units (diode – monocgromatic light, need of more diods)
- Laser (strictly monochromatic light)

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Polymerization units – output energy

Quarz halogen	600 -800 mW/cm^2
LED (3.generation)	1000 -1800 mW/cm^2 modr 50 – 100 mW/cm^2 fialové
Plasma	1500 - 2000mW/cm^2

Output energy and time of polymerization

- Recomended power is 12000 – 16000 mJ/cm^2

12 000 mWs/cm^2

measured intensity mW/cm^2

Time in seconds

Usually 20 s
Radiometer ois recommended

Photoinitiators

- Kafrchinon
  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

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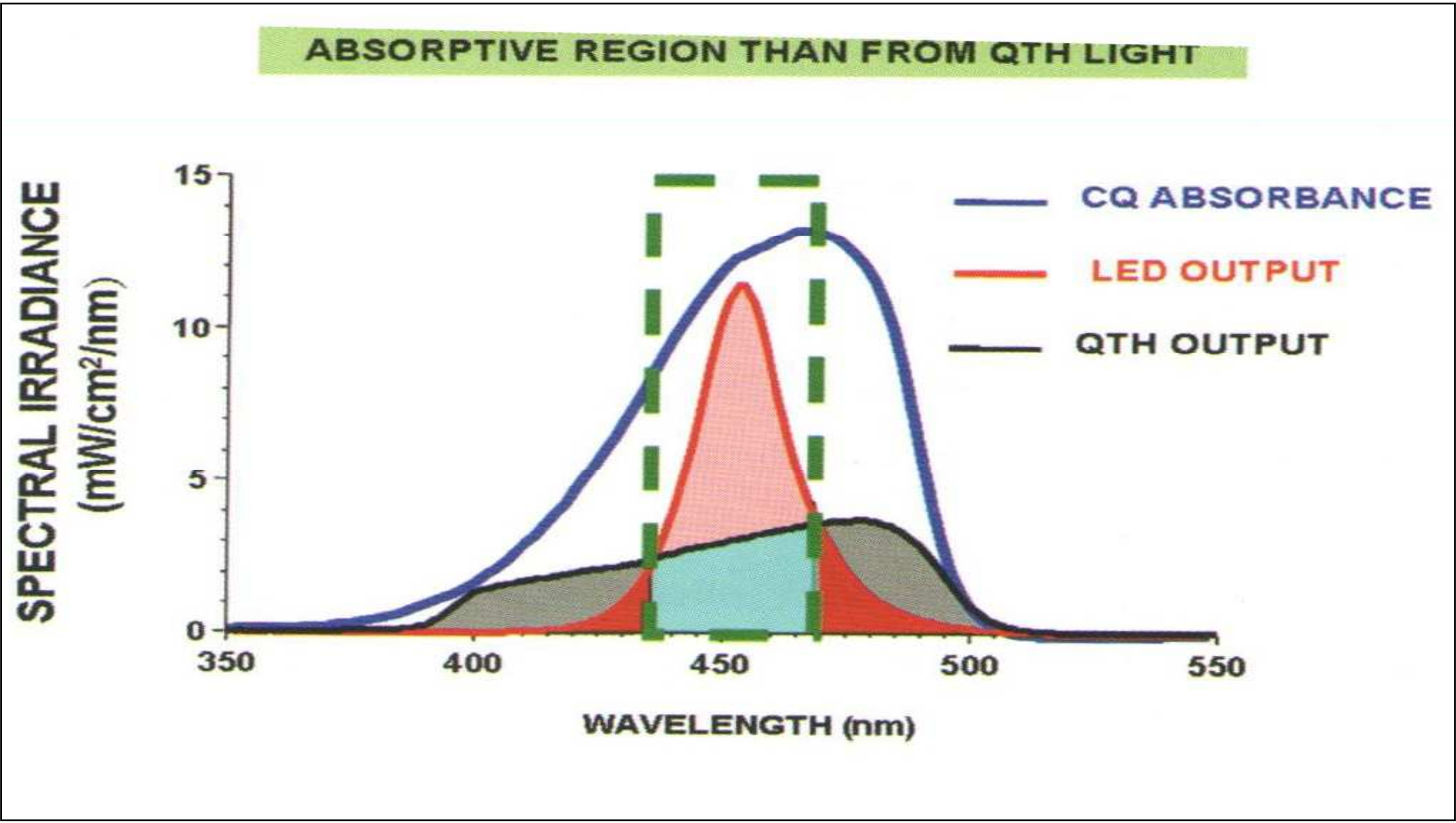
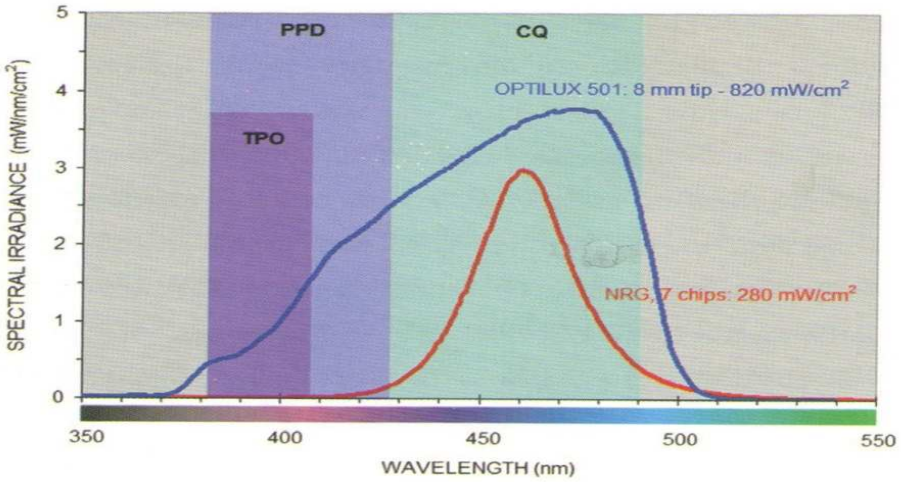
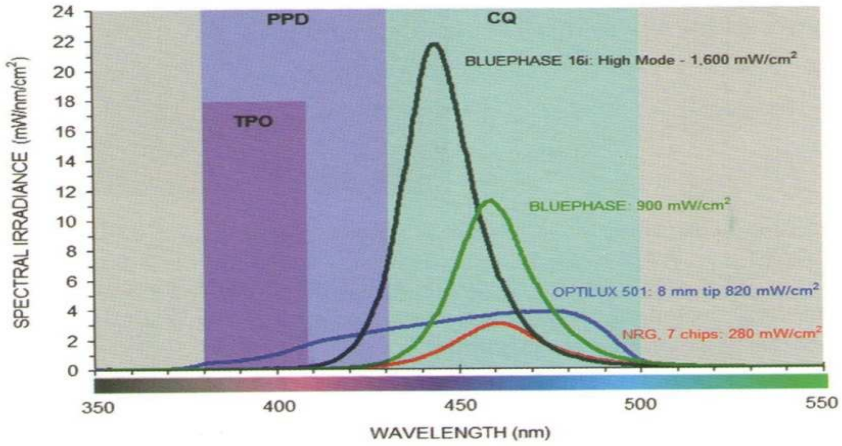
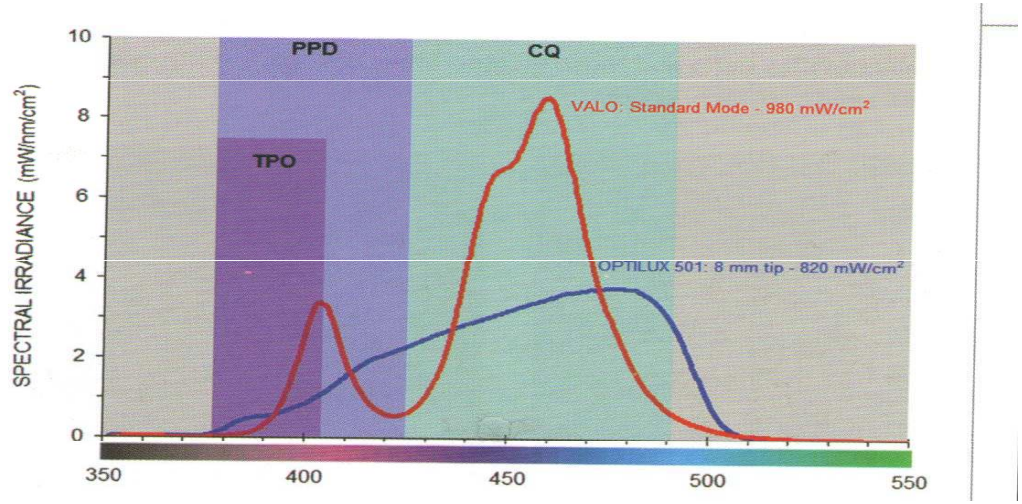
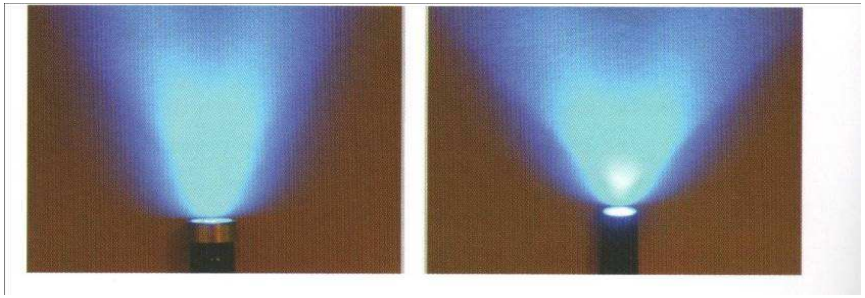

ABSORPTIVE REGION THAN FROM QTH LIGHT
SPECTRAL IRRADIANCE
(mW/cm²/nm)
15
10
5
0
350
400
450
500
550
WAVELENGTH (nm)
CQ ABSORBANCE
LED OUTPUT
QTH OUTPUT


PPD
CQ
TPO
OPTILUX 501: 8 mm tip - 820 mW/cm²
NRG, 7 chips: 280 mW/cm²
SPECTRAL IRRADIANCE (mW/nm/cm²)
WAVELENGTH (nm)
0
1
2
3
4
5
350
400
450
500
550


PPD
CQ
TPO
BLUEPHASE 16i: High Mode - 1,600 mW/cm²
BLUEPHASE: 900 mW/cm²
OPTILUX 501: 8 mm tip 820 mW/cm²
NRG, 7 chips: 280 mW/cm²
SPECTRAL IRRADIANCE (mW/nm/cm²)
WAVELENGTH (nm)
0
2
4
6
8
10
12
14
16
18
20
22
24
350
400
450
500
550


PPD
CQ
TPO
VALO: Standard Mode - 980 mW/cm²
OPTILUX 501: 8 mm tip - 820 mW/cm²
SPECTRAL IRRADIANCE (mW/nm/cm²)
0
2
4
6
8
10
350
400
450
500
550

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/cm^2
- Continuous two step curing
- 10 s 150 W/cm^2 then 750 mW/cm^2
- 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/cm^{2}unit is turn off. 3 min pause
- Final curing 600 mW/cm^2

- 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

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Composite materials with high viscosity

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

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Bulk fill

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

Group of various materials:

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

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Sonic Fill

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

Sonic „activation" – vibration decrease viscosity

Internal dispersion of light

Long term expeerience?

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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.)

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Working procedure and variables affecting the bonding

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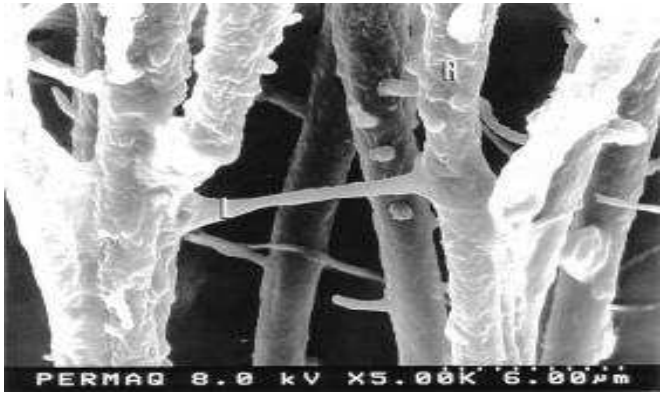
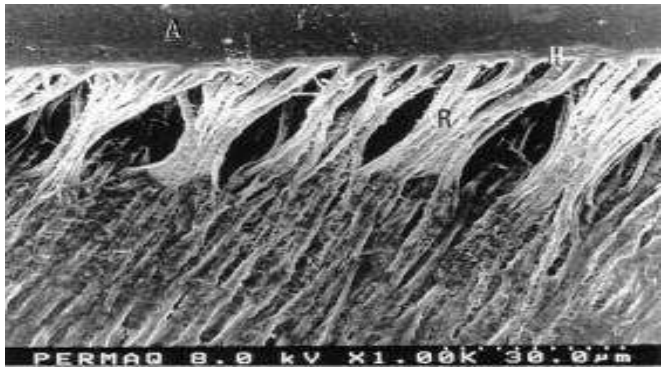
What affects the quality of bonding?

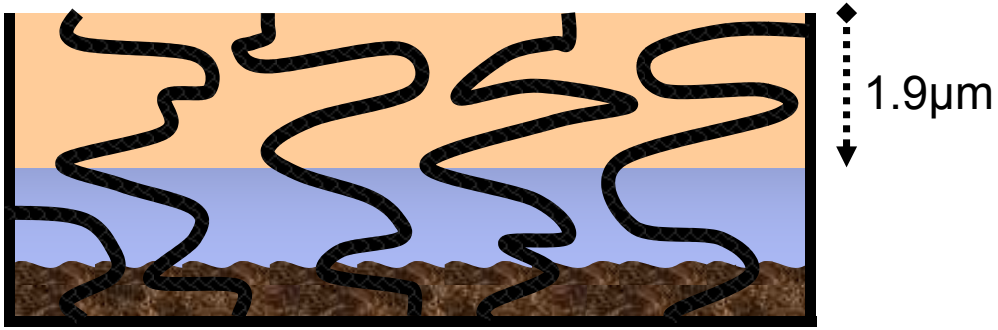




Variables that affect quality of bonding

1) Etching

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



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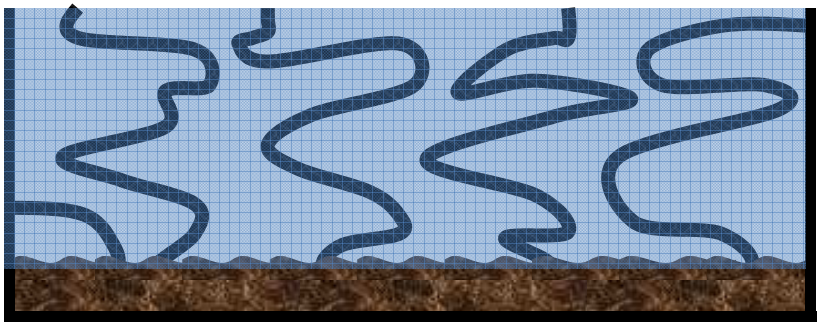
Variables that affect quality of bonding

2) Drying dentin

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



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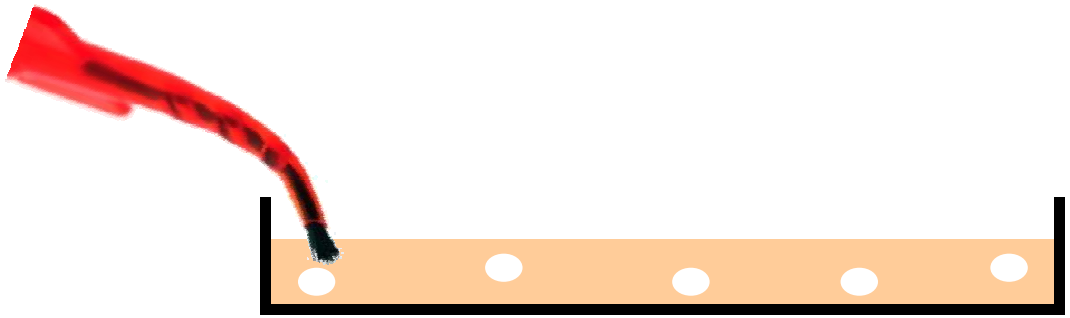
Variables that affect quality of bonding

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.



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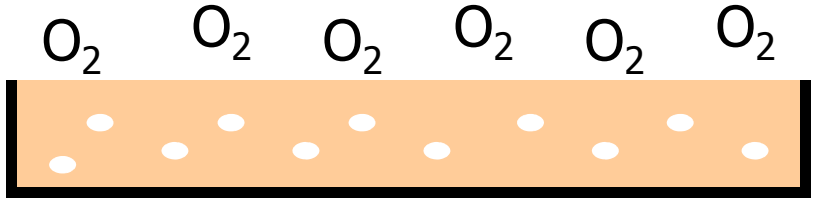
Variables that affect quality of bonding

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.



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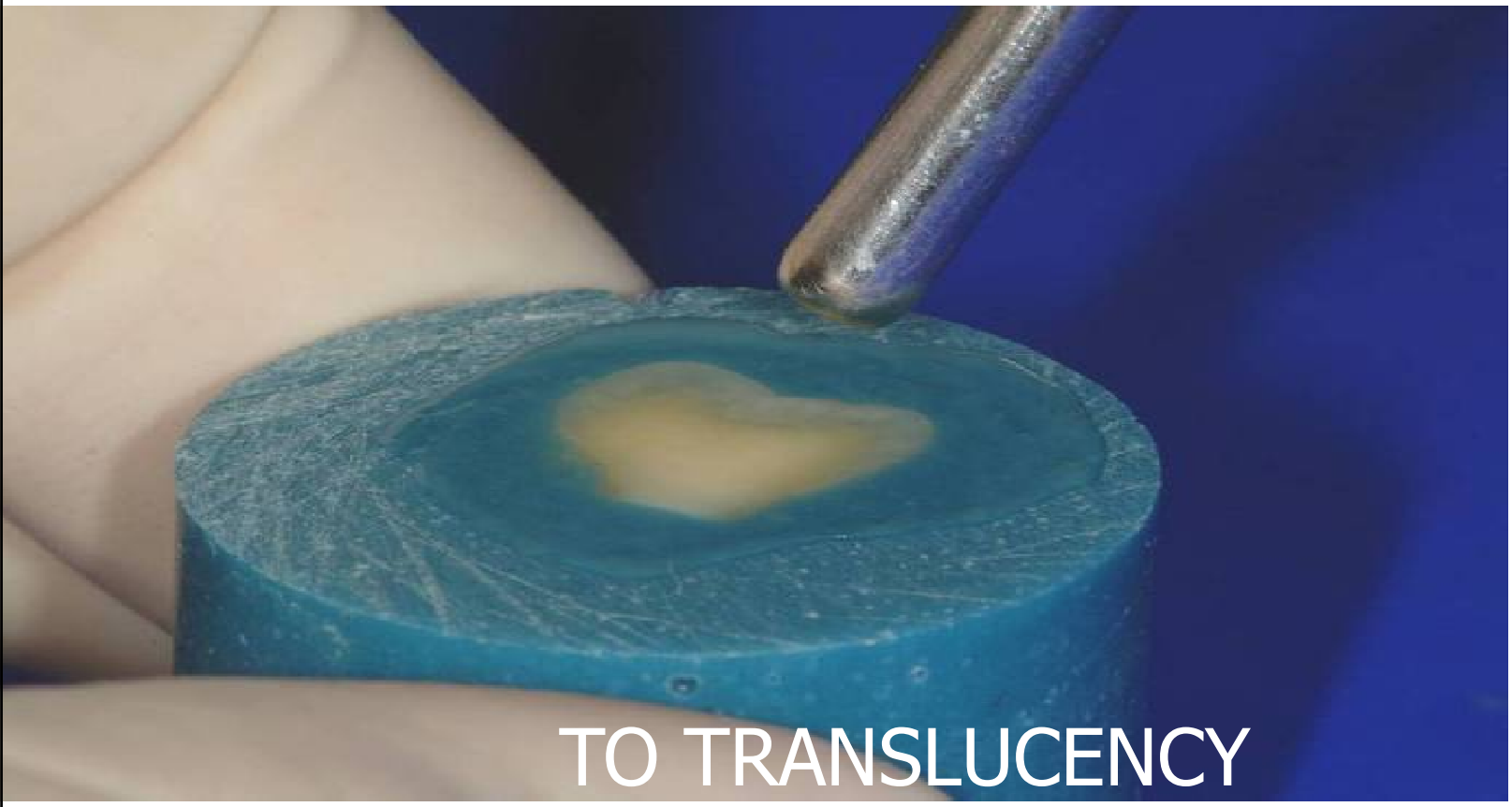
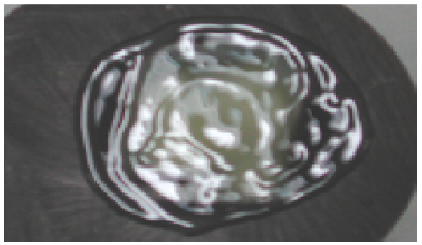
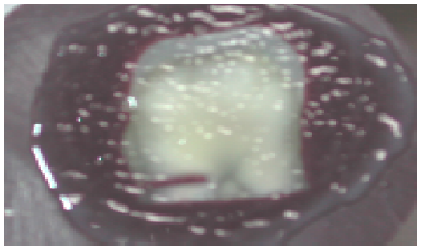
Air thin / Dry



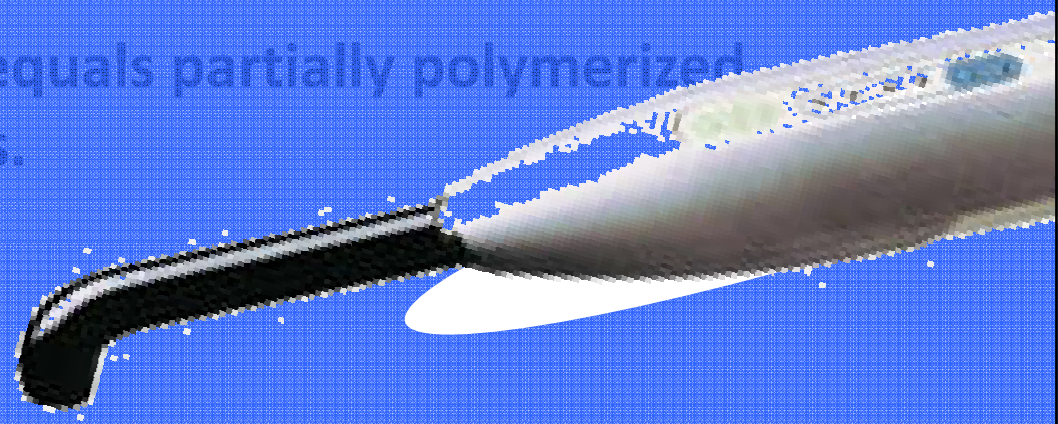




Variables that affect quality of bonding

5) Light curing

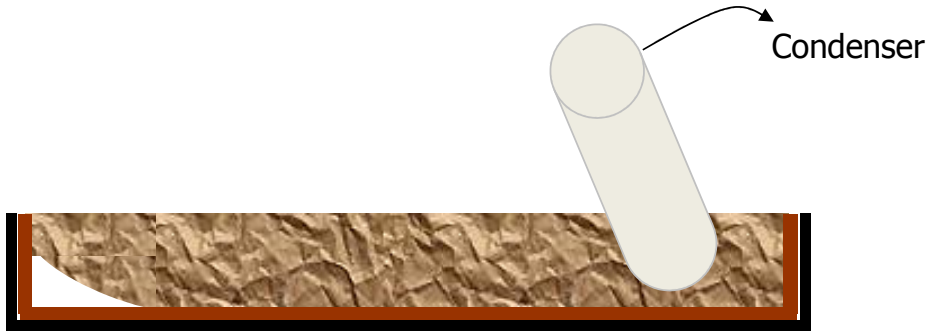
Too short or insufficient light cure equals partially polymerized resins.



Variables that affect quality of bonding

6) Composite Placement

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



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Variables that affect quality of bonding

7) Contamination

- **Blood**
- **Sulcular fluid**
- **Saliva**
- **etc…**

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Variables that affect quality of bonding

8) Deteriorated product

- **Expired**
- **Volatilized**

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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*

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Other indication

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

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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

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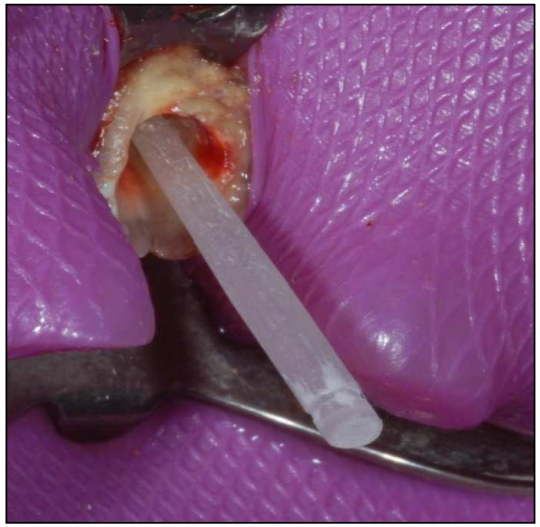
Postendo – post and core



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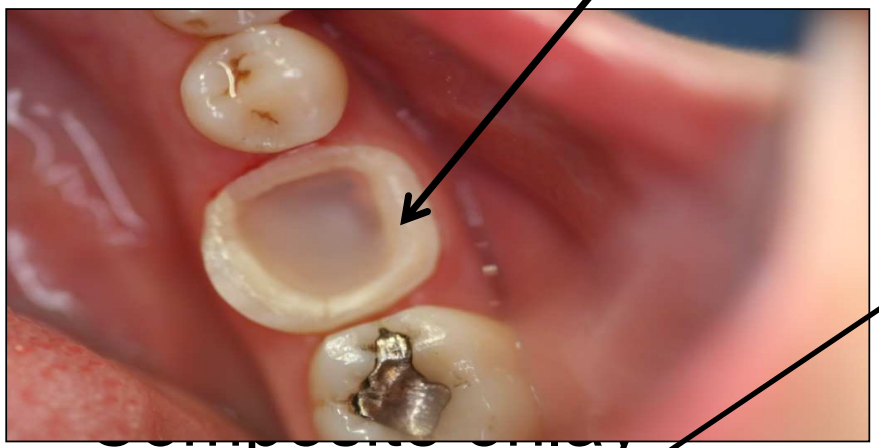
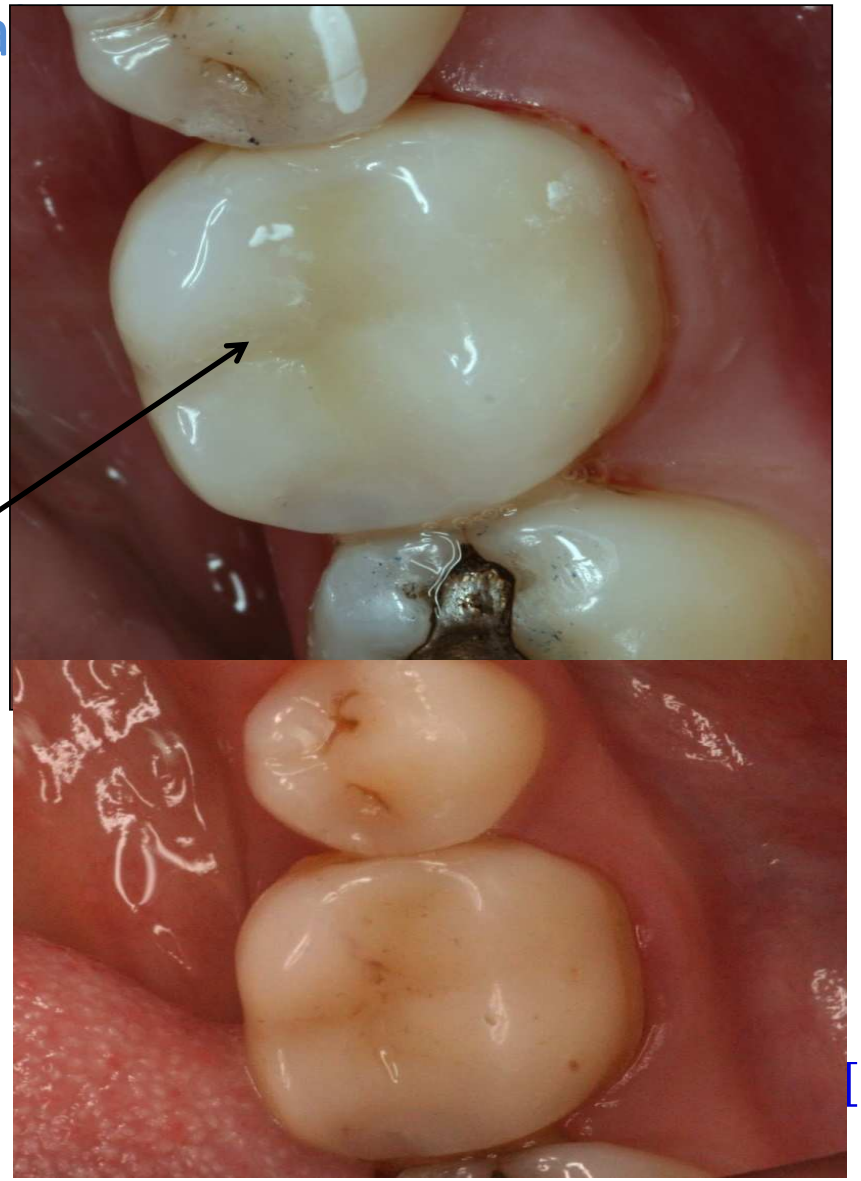
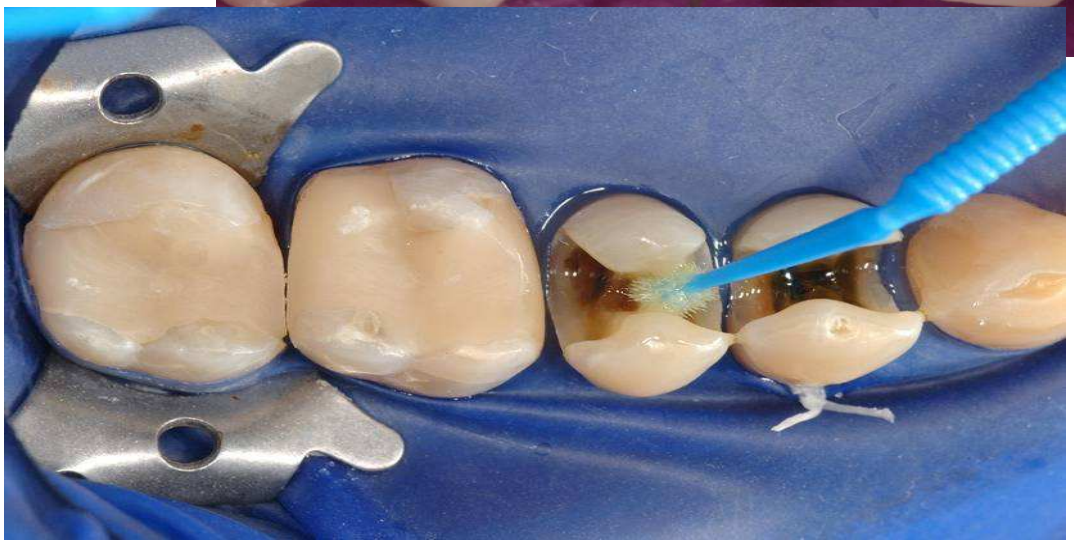
Postendo using flowa and onlay

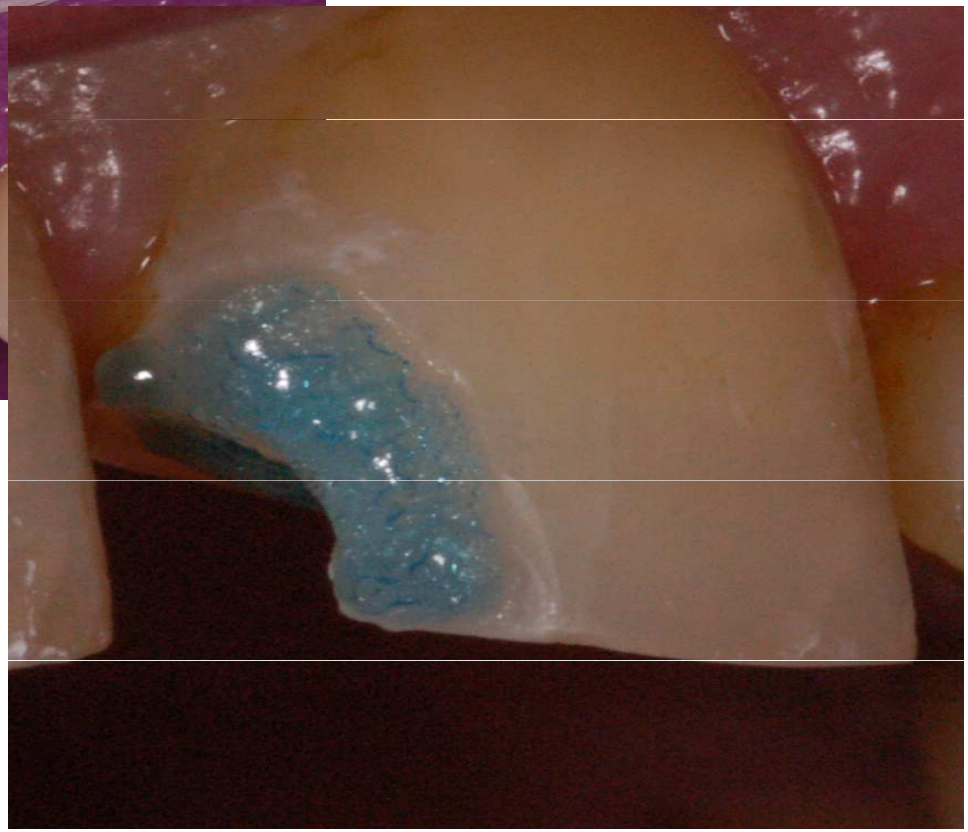
- Flowable at the bottom

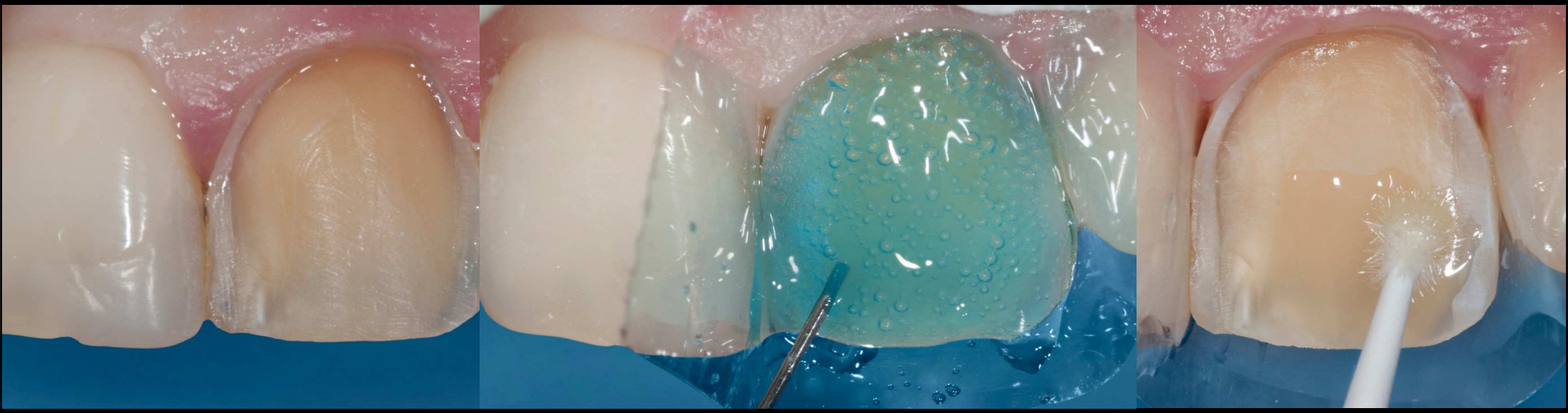


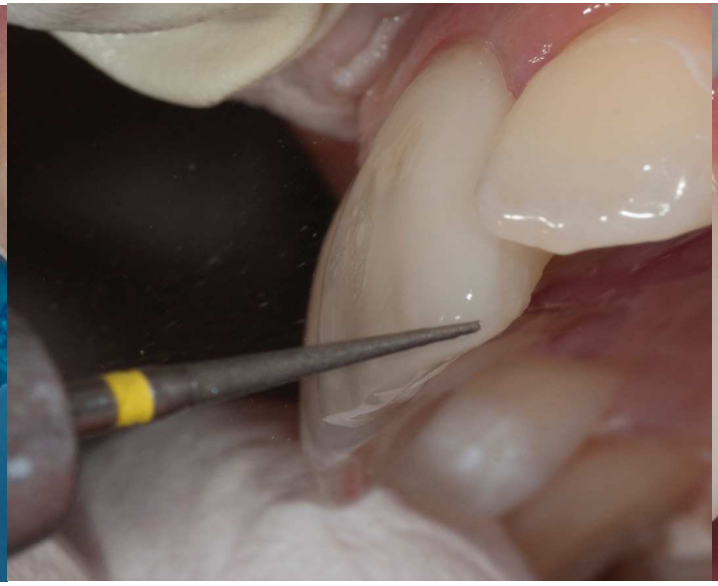
- Onlay after 8 years







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EMPTY
FULL
PANAVIA 21 DISPENSER
KURARAY MEDICAL INC.
OXYGUARD II


dentine
Rebilda DC

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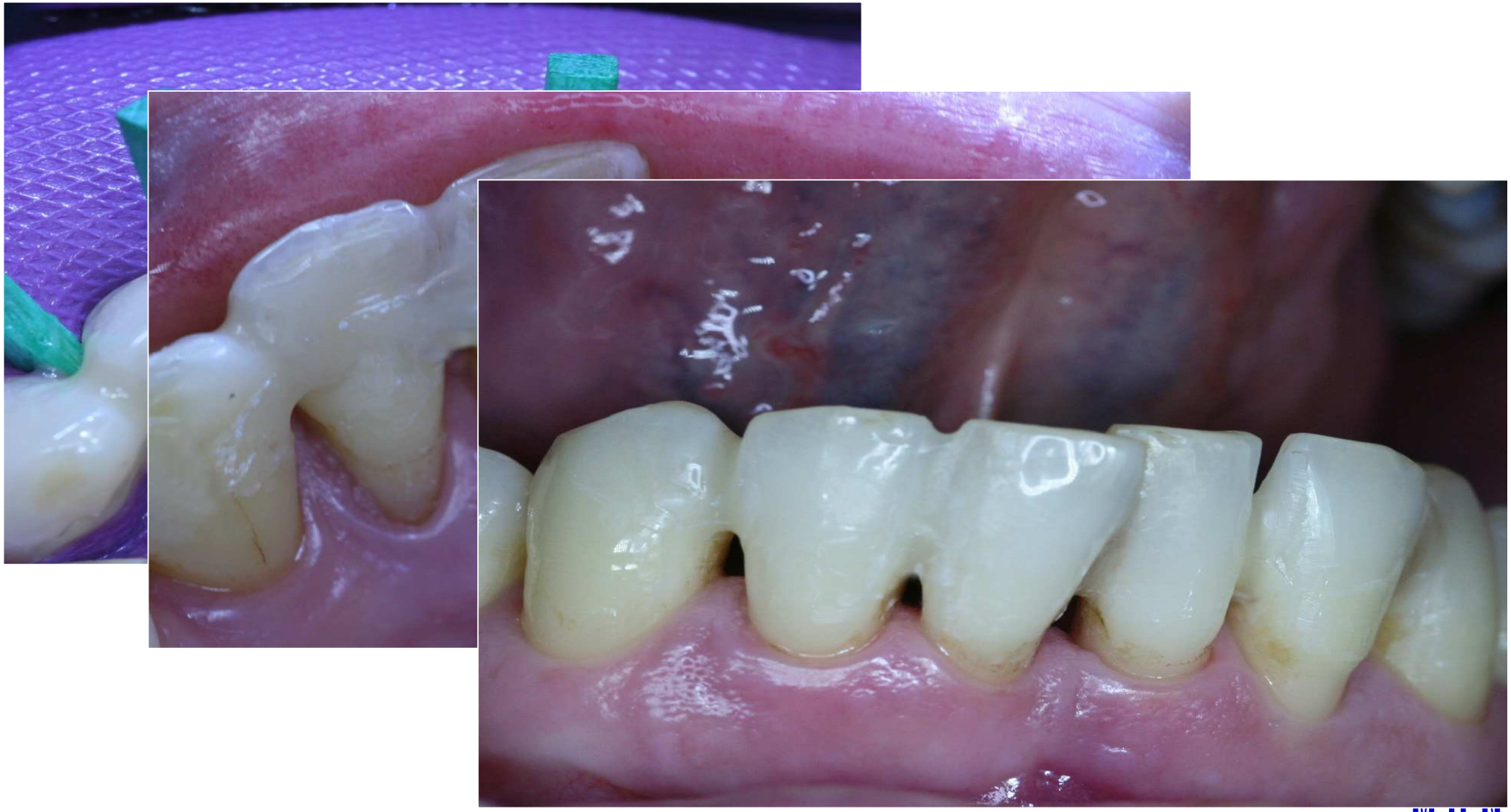

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