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Two component micro injection moulding for moulded interconnect devices

2k moulding for MIDs

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Publication date:
2008

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Citation (APA):
Islam, M. A. (Author), & Hansen, H. N. (Author). (2008). Two component micro injection moulding for moulded interconnect devices: 2k moulding for MIDs. Sound/Visual production (digital)

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Two component micro injection moulding for moulded interconnect devices (MIDs)

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Department of Mechanical Engineering
Technical University of Denmark

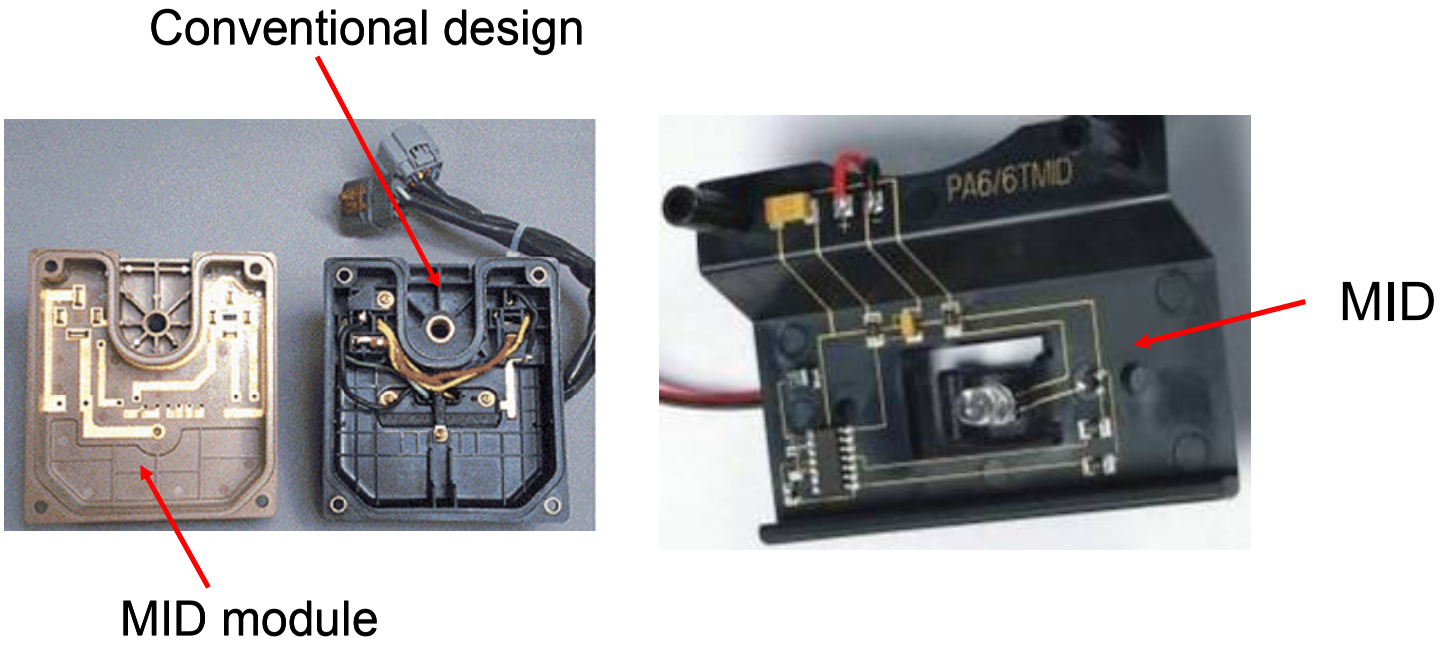
Polymetal conference
DTU, 26 Nov 2008

Outline

- Introduction to MID
- MID by 2k moulding
  - -Polymer-polymer bond strength
  - -Polymer-polymer interface
- Selective metallization
- Demonstrator MID
- Summary and conclusion

Moulded Interconnect Device (MID)

The MID is an injection moulded plastic part integrating electrical and mechanical functionalities on a single device.



Pros and cons of MIDs

Pros:

- Three dimensional circuit pattern
- Reduced number of part components
- Less assembly operation
- Reduced production cost

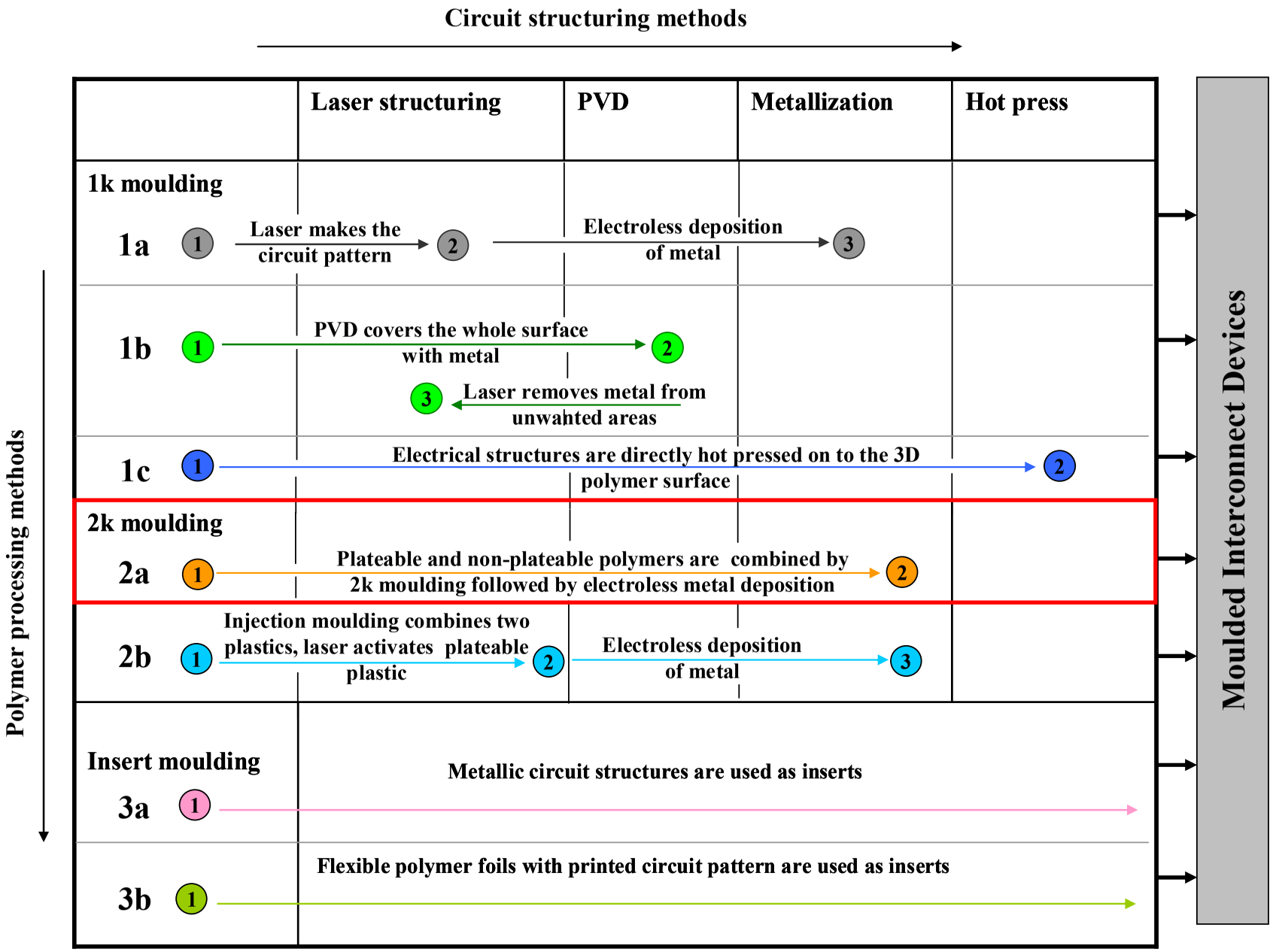
Cons:

- Requires expensive machines and tools
- Not suitable for small production volume
- Shortage of knowhow

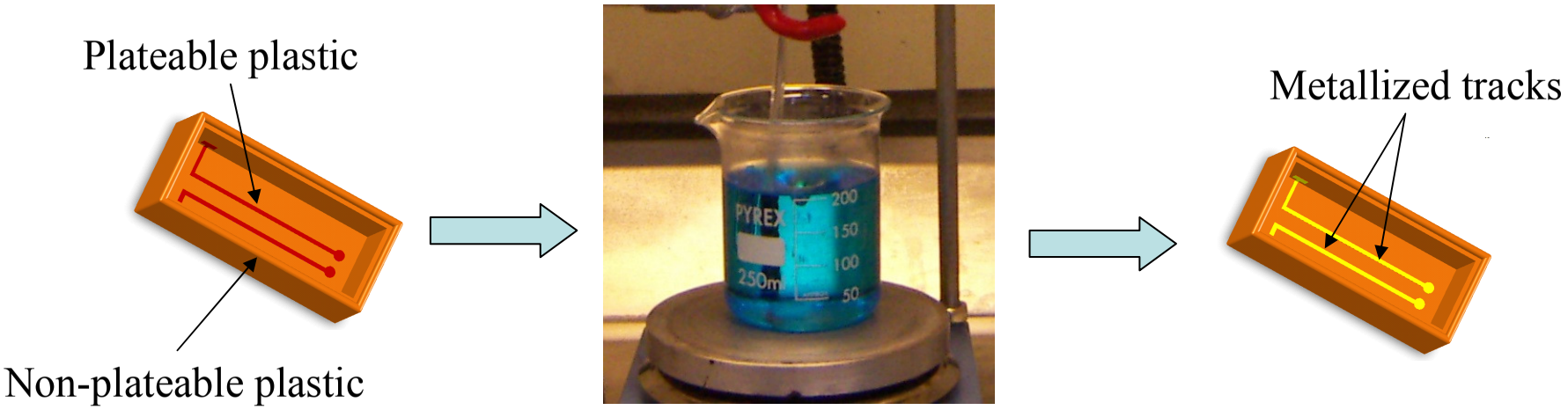
Application of MIDs

- **Mobile phone** (antenna, housing, sockets)
- **Automotive applications** (door locking mechanism, dashboard switches, multifunctional steering wheel, turbocharger regulator, seat adjuster and sun hood opener)
- **Air plane industry** (no smoking illumination sign, pressure and flow sensors for air-conditioning, automatic overload detection mechanism)
- **Smart pen, Hearing aid, Flipchip**

MID process chains



Two component injection moulding for MIDs



Two component moulding → **Electroless deposition of metal** → **MID**

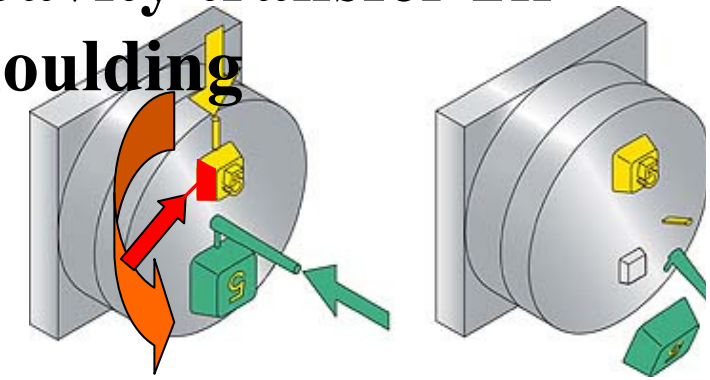
Two component (2k) injection moulding

-Combine two different polymers

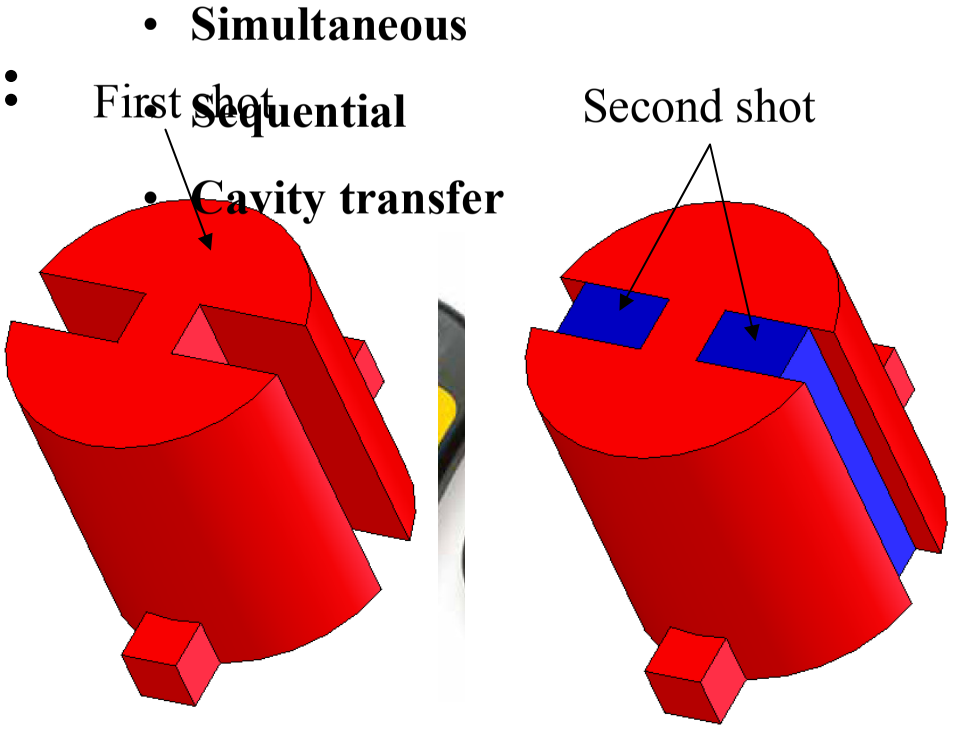
-Variant of 2k moulding :

- **Simultaneous**
- **Sequential**
- **Cavity transfer**

-Cavity transfer 2k moulding



Source: www.arburg.com



Challenges of 2k moulding

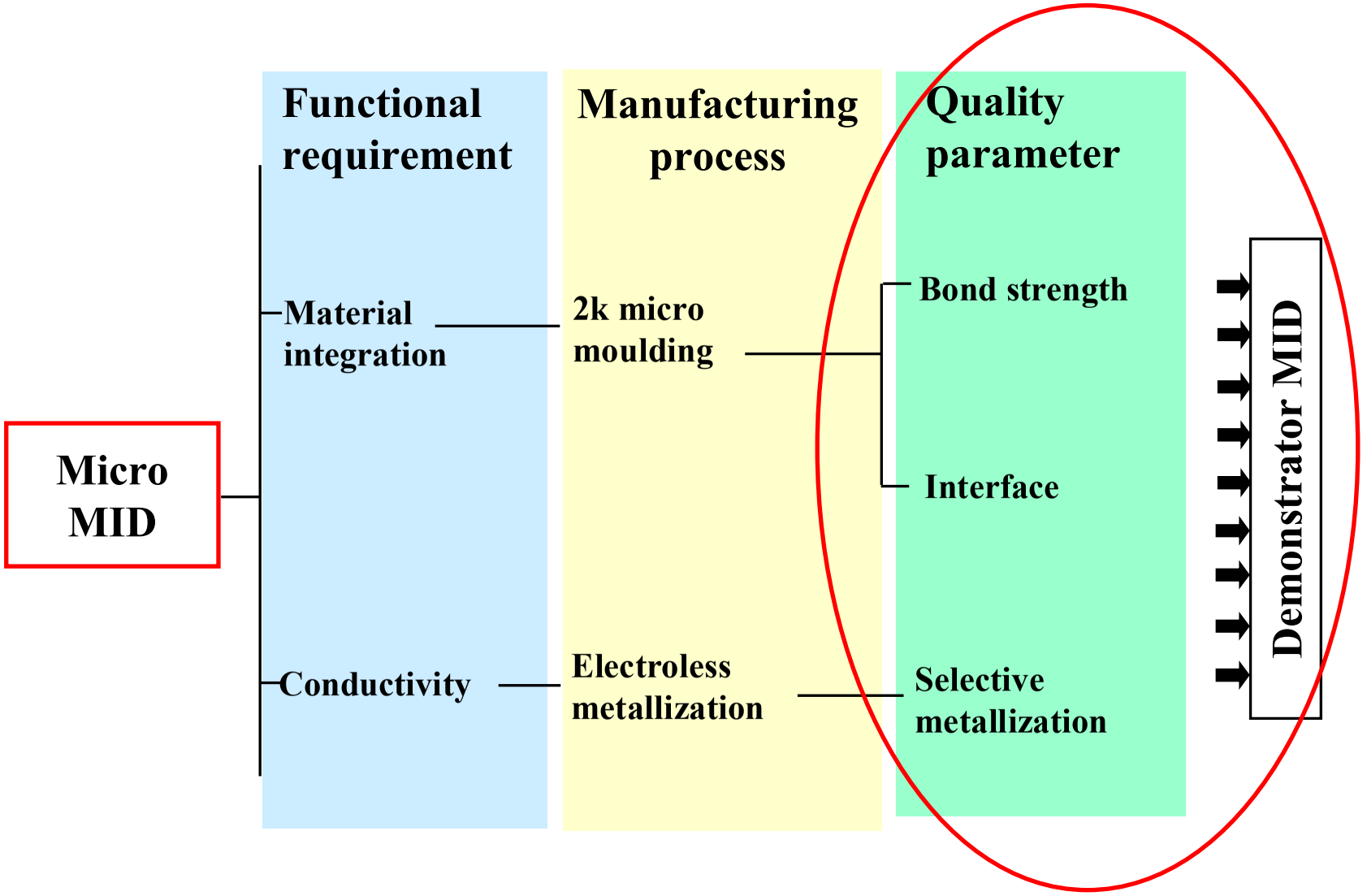
-Reasonable adhesion between the two polymers

-Well-defined interfaces between the two polymers

More for MIDs…

-Selective metallization

-Micro scale selective metallization


Micro MID
Functional requirement
Material integration
Conductivity
Manufacturing process
2k micro moulding
Electroless metallization
Quality parameter
Bond strength
Interface
Selective metallization
Demonstrator MID

Investigation of the polymer-polymer bond strength

-Suitable polymer pairs for 2k applications

-Factors influencing bond strength

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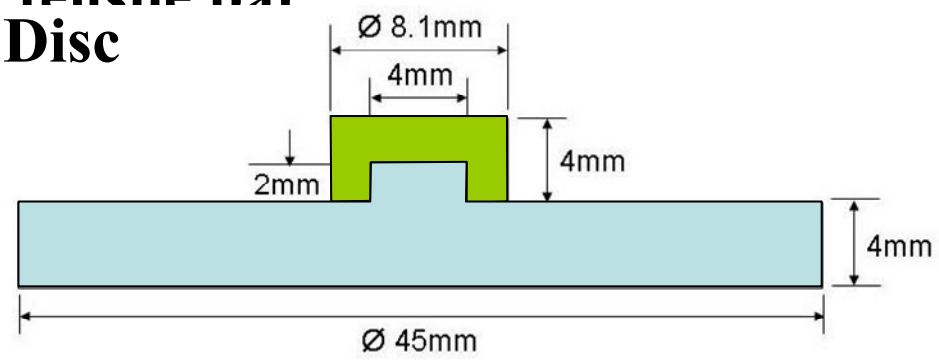
Material list

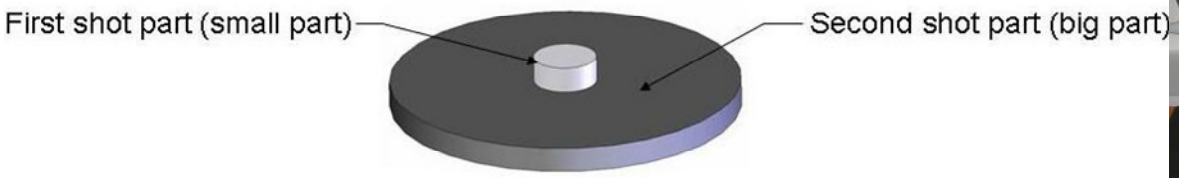
No	Name	Abbreviation	Trade name	Grade	Manufacturer
1	Polyetherimide	PEI	Ultem	1000	GE
2	Polyetherimide	PEI	Ultem	2312EPR	GE
3	Polyetheretherketone	PEEK	Victrex	150GL30	Victrex
4	Polyoxymethylene	POM	Hostaform	C27021	Ticona
5	Liquid crystal polymer	LCP	Vectra	E820i	Ticona
6	Liquid crystal polymer	LCP(Pd)	Vectra	E820i Pd	Ticona
7	Liquid crystal polymer	LCP(LDS)	Vectra	E820i LDS	Ticona
8	Polybutylen terephthalate	PBT	Pocan	DP7102	Lanxess
9	Polybutylen terephthalate	PBT	Vestodur	GF30FR LDS	Degussa
10	Polyphenyleneether blends	(PPE+PA+GF)	Noryl	GTX810	GE
11	Polyphenyleneether blends	(PPE+PA)	Noryl	GTX964	GE
12	Polyphenyleneether blends	(PPE+HIPS)	Noryl	GFN1520V	GE
13	Polystyrene	PS	Polystyrol	143E	BASF
14	Polystyrene	PS	Polystyrol	158K	BASF
15	Polystyrene	PS	Polystyrol	158KGf30	BASF
16	Acrylonitrilebutadienestyrene	ABS	Terluran	997VE	BASF
17	Polycarbonate	PC	Lexan	500R	GE

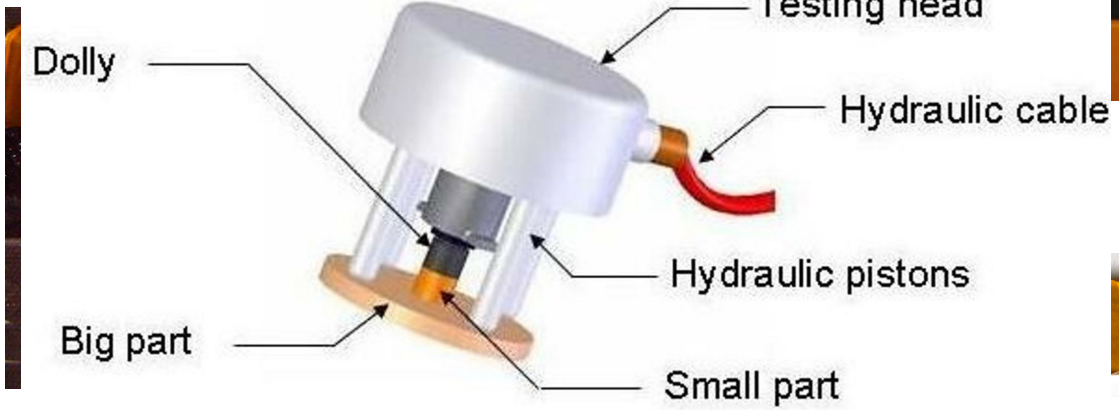
Polymer-polymer bond strength investigation

2k tensile bar

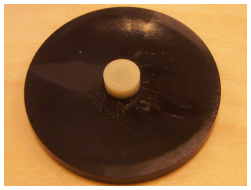
2k Disc

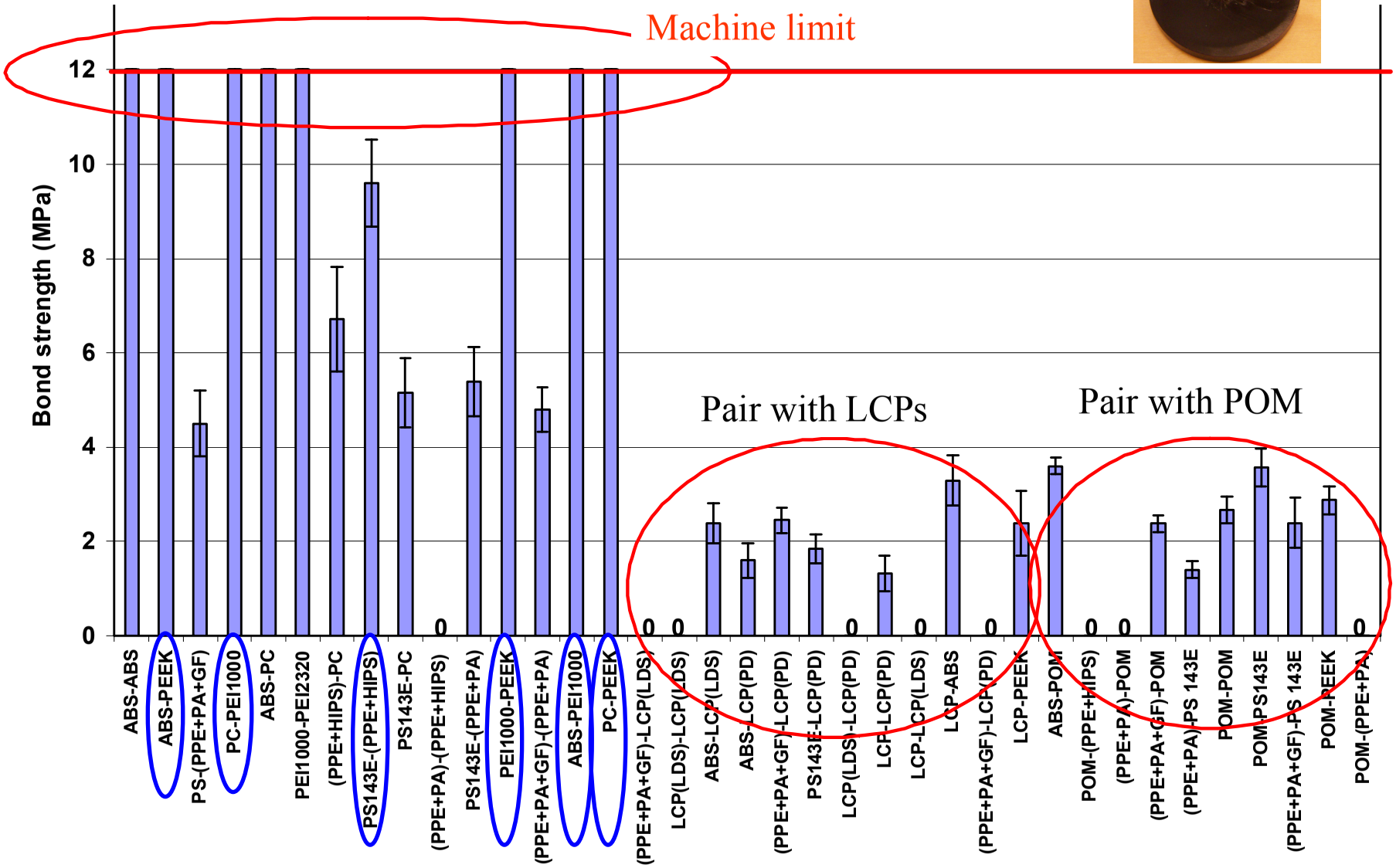




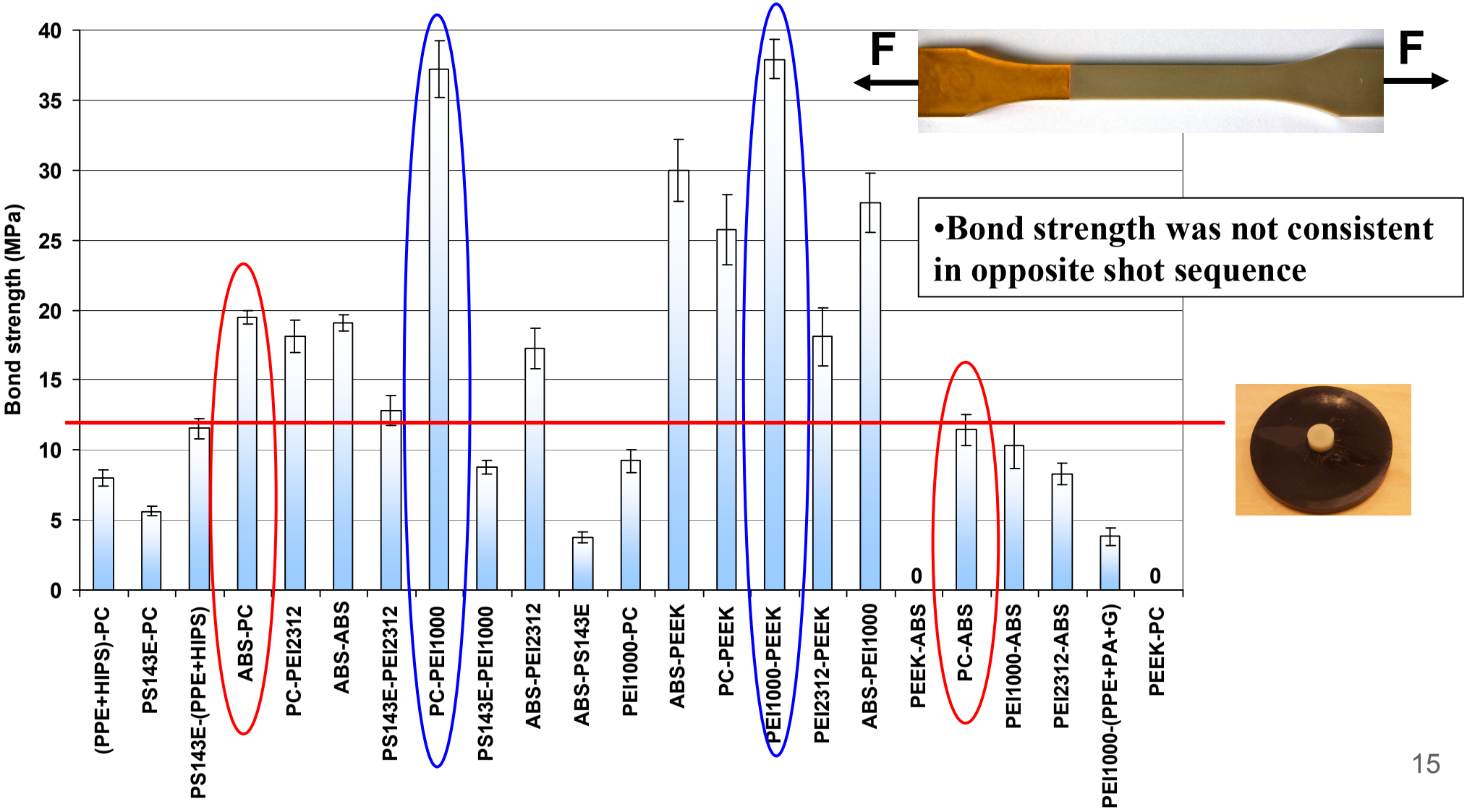


Pull test results

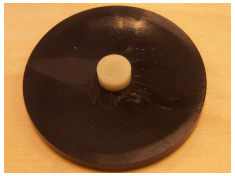


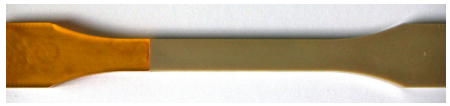


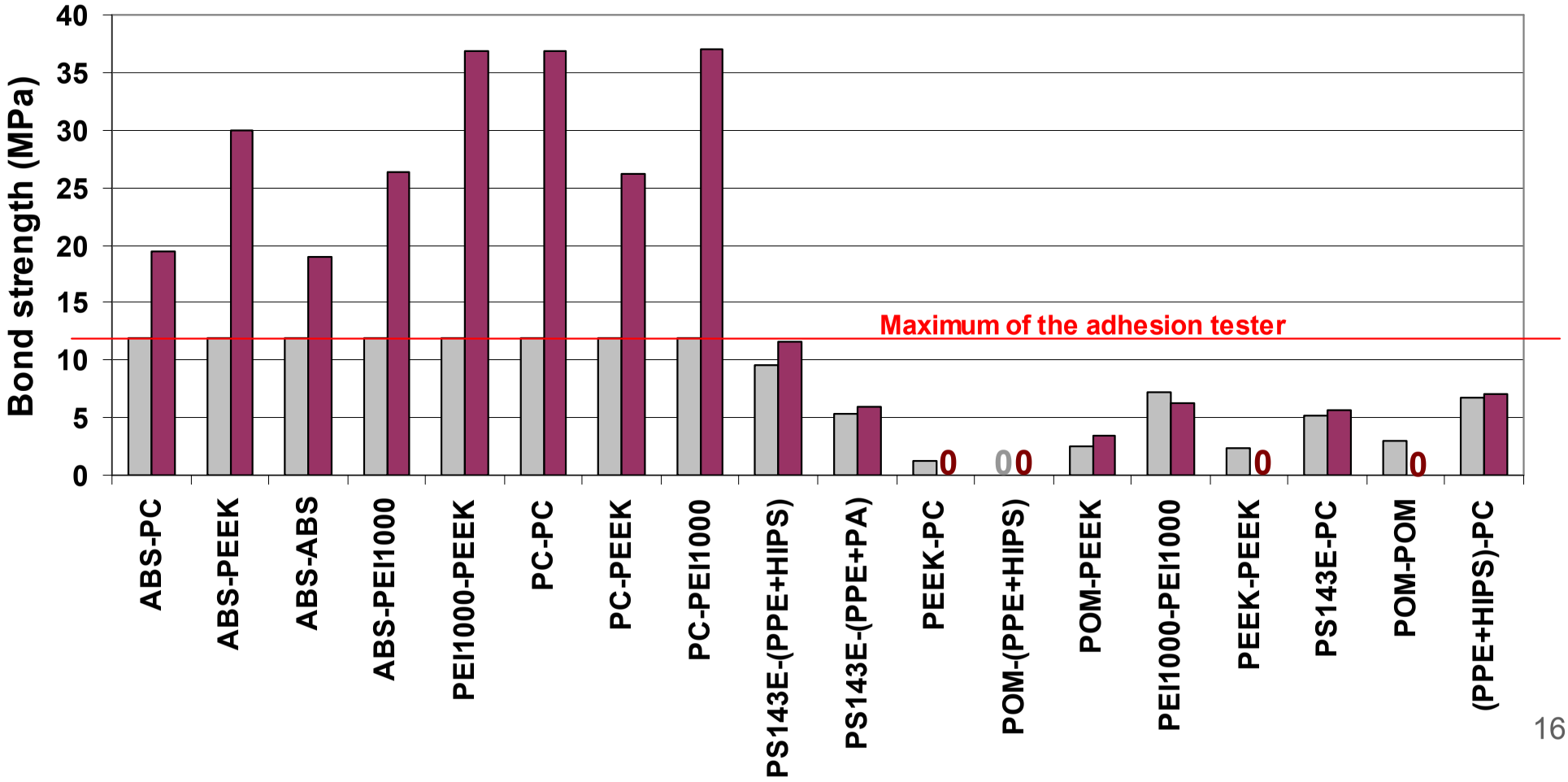
Tensile test results (2k tensile bar)



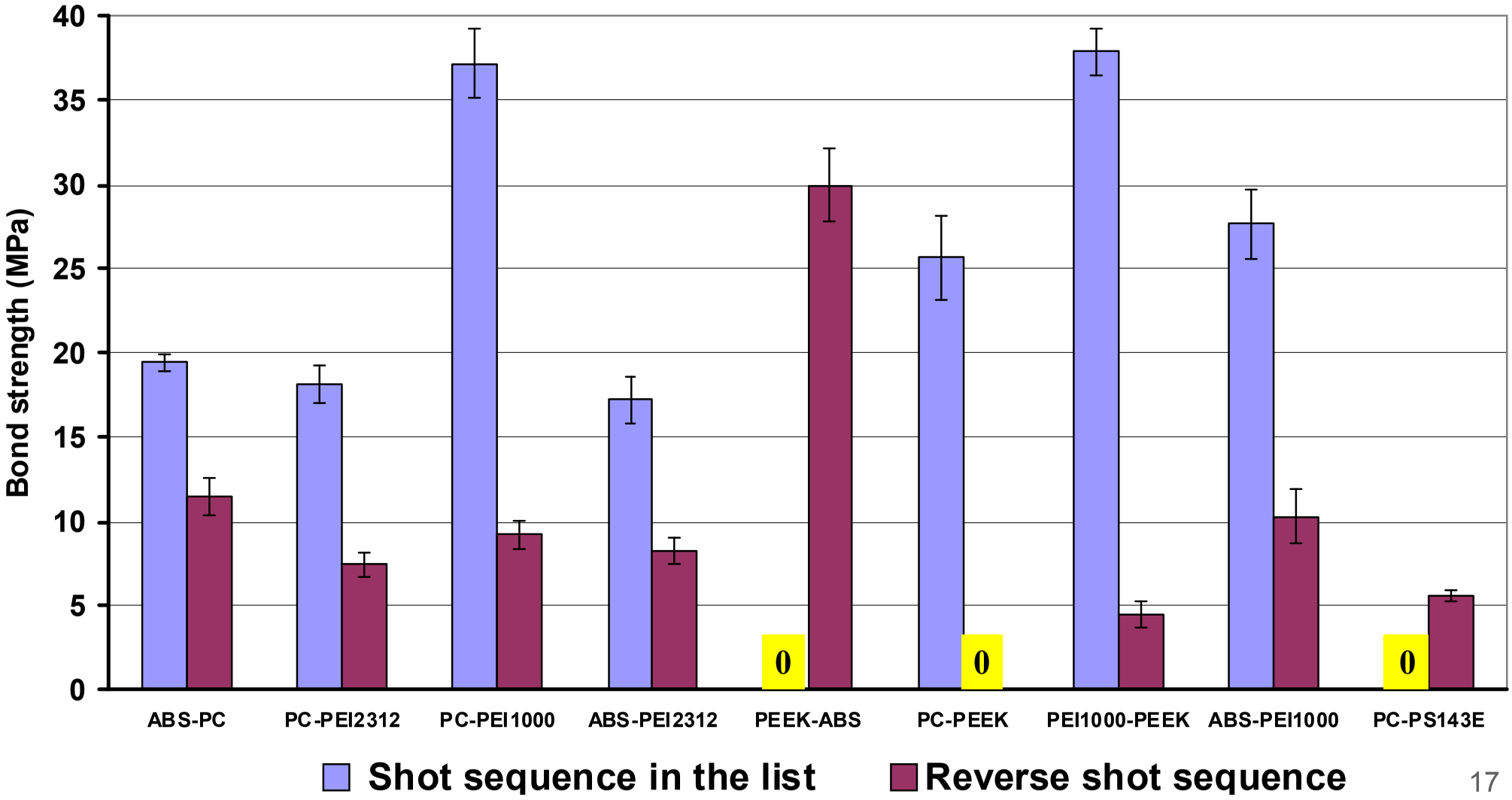
Comparative bond strength







Bond strength as a function of shot sequences

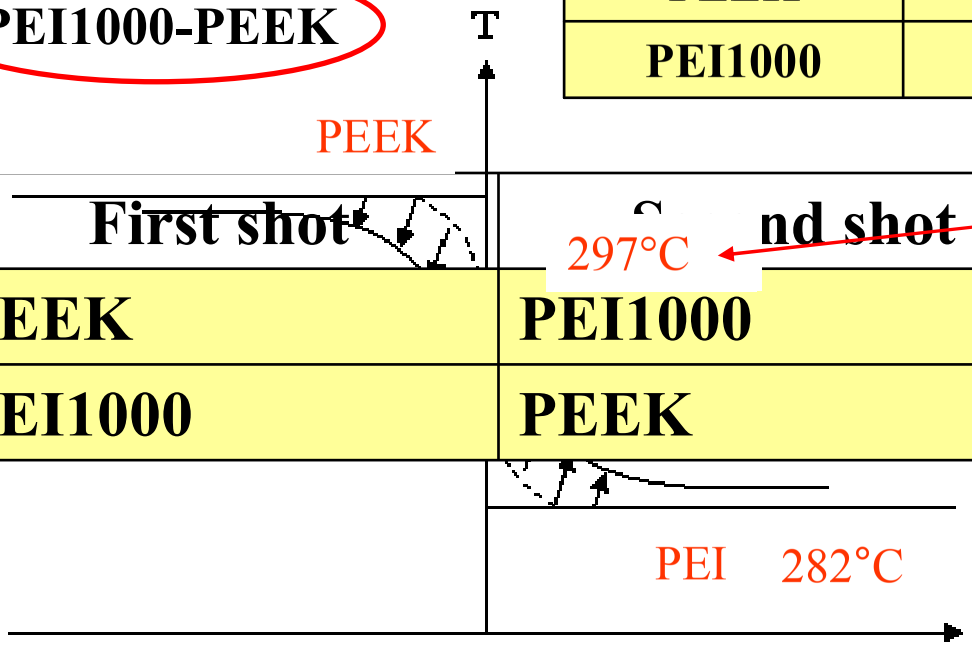


Bond strength as a function of shot sequences

PEEK-PEI1000

PEI1000-PEEK

First shot	Second shot	Bond strength (MPa)
PEEK	PEI1000	4
PEI1000	PEEK	37



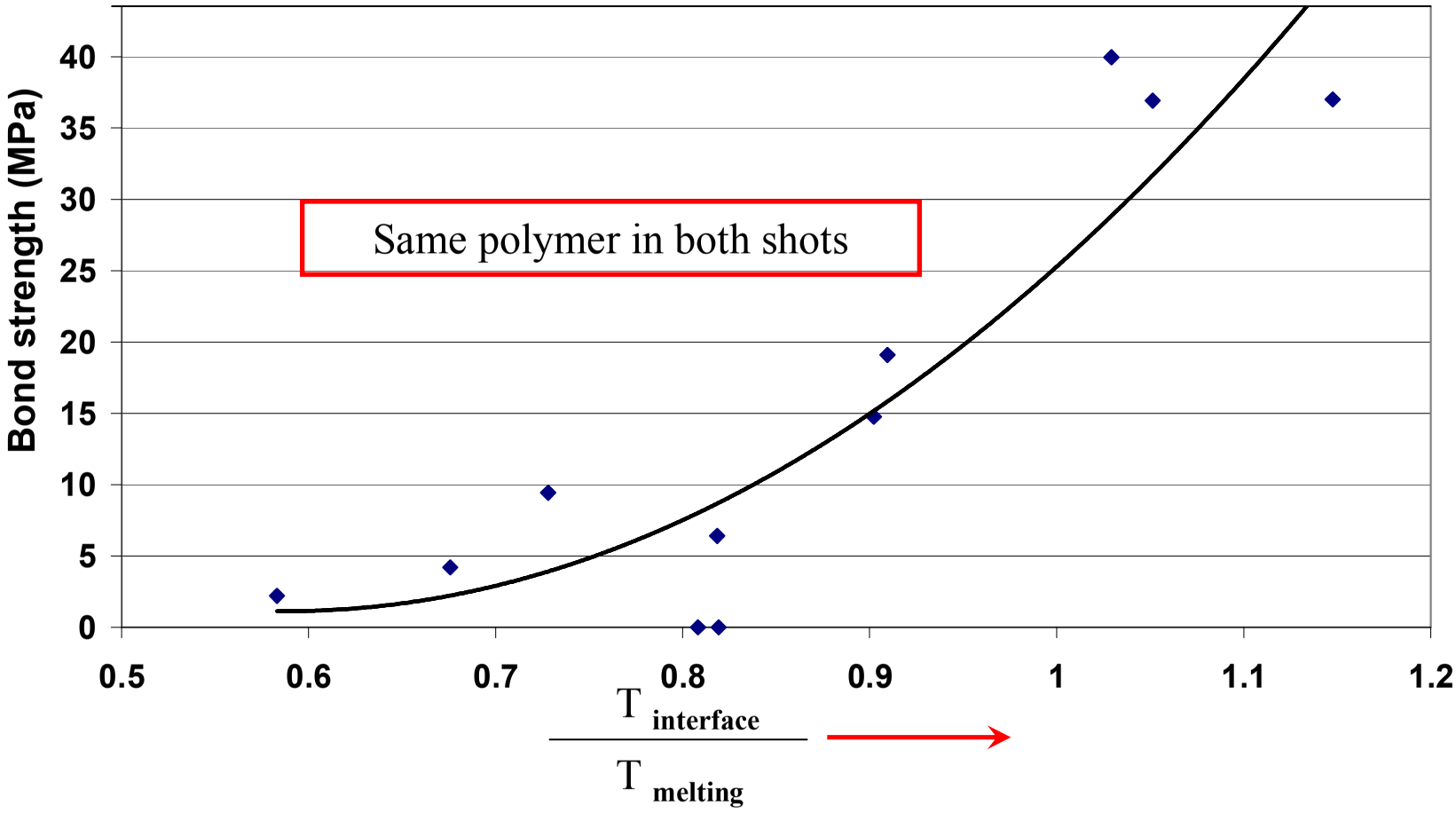
$$T_i = \frac{b_1 T_1 + b_2 T_2}{\text{Bond strength}}$$

First shot	Second shot	Bond strength (MPa)
PEEK	PEI1000	4
PEI1000	PEEK	37

Good bonding

$T_i > T_{melting\ 1}$

Effects of interface temperature

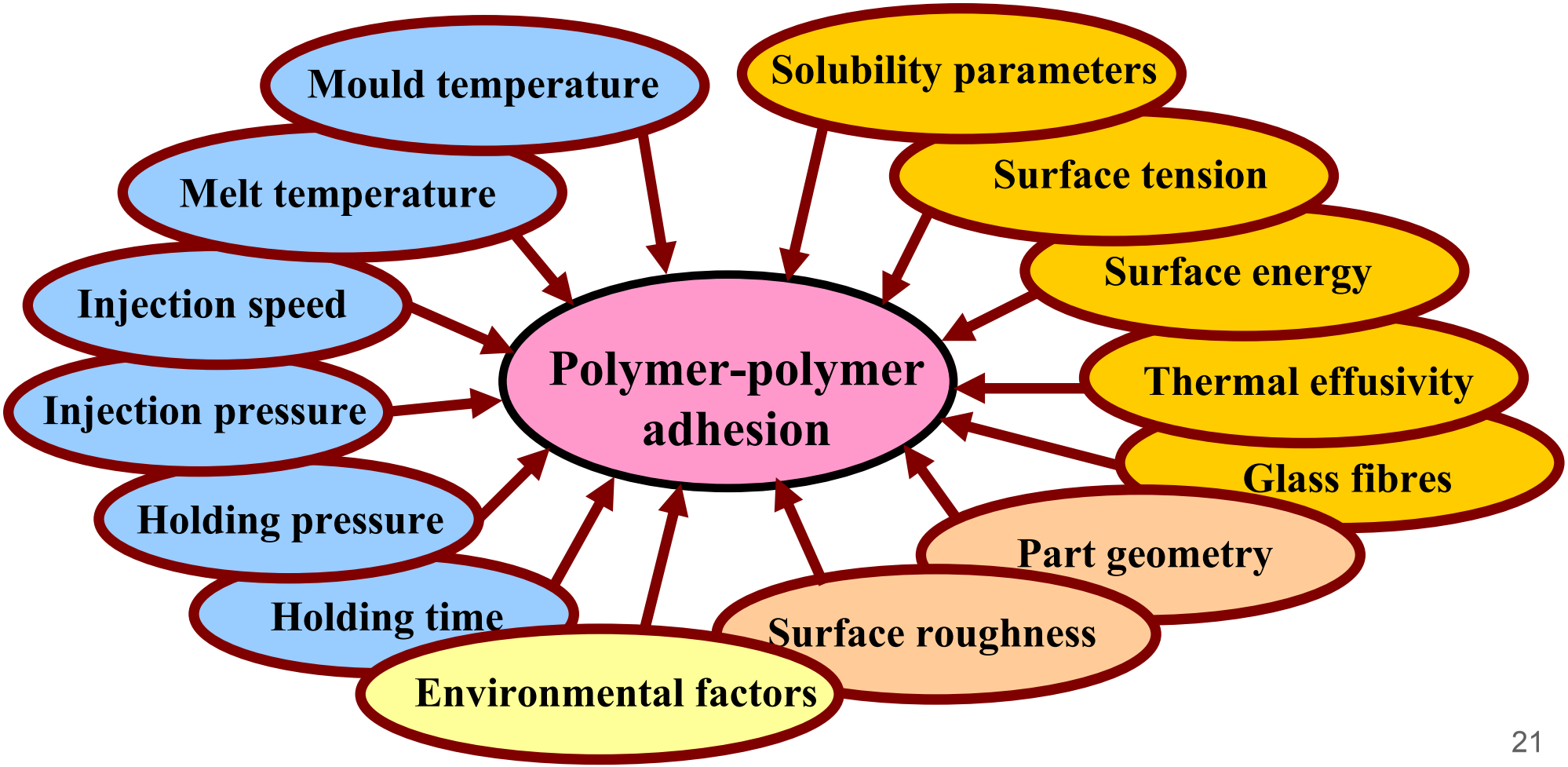


$$\frac{T_{interface}}{T_{melting}} = \frac{\text{Interface temperature}}{\text{Melting point of the inlay part}} \geq 1 \quad \text{(For good bonding)}$$

Suitable polymer pairs for 2k applications

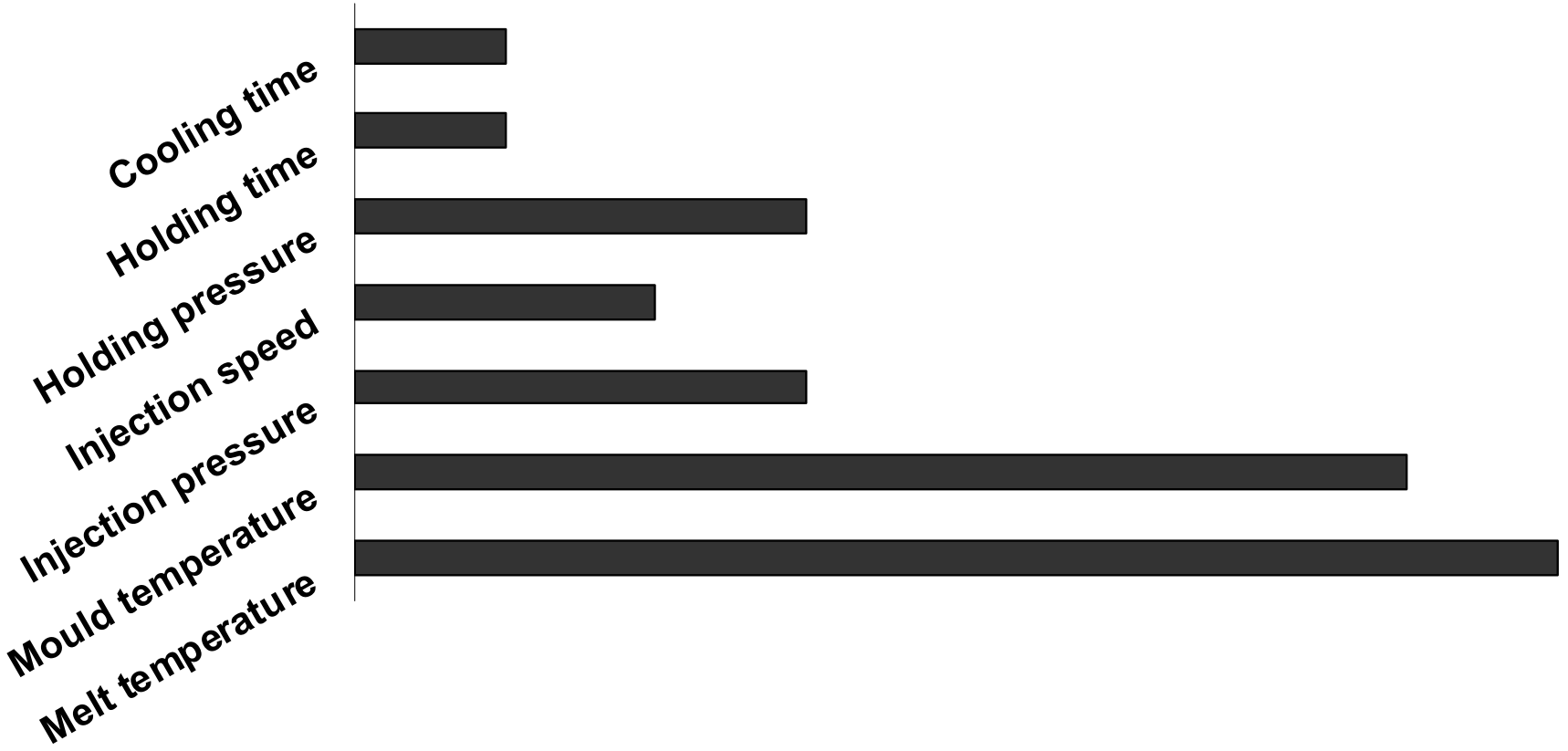
NO	Material pairs (first shot-second shot)	Bond strength with 2k tensile bar (MPa)
1	PEI1000-PEEK	38
2	PC-PEI1000	37
3	ABS-PEEK	30
4	ABS-PEI1000	27
5	PC-PEEK	26
6	ABS-PC	19
7	PEI2312-PEEK	18
8	PC-PEI2312	18
9	ABS-PEI2312	17
10	PS-PEI2312	13
11	PS-(PPE+HIPS)	12

Investigations of the factors affecting polymer-polymer bond strength

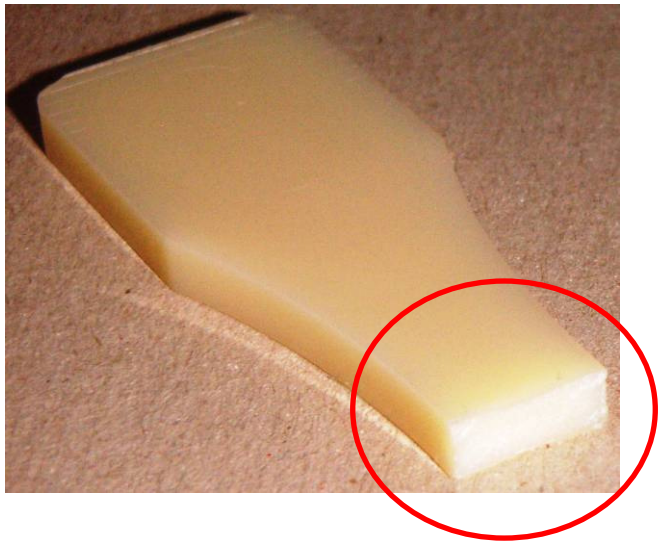


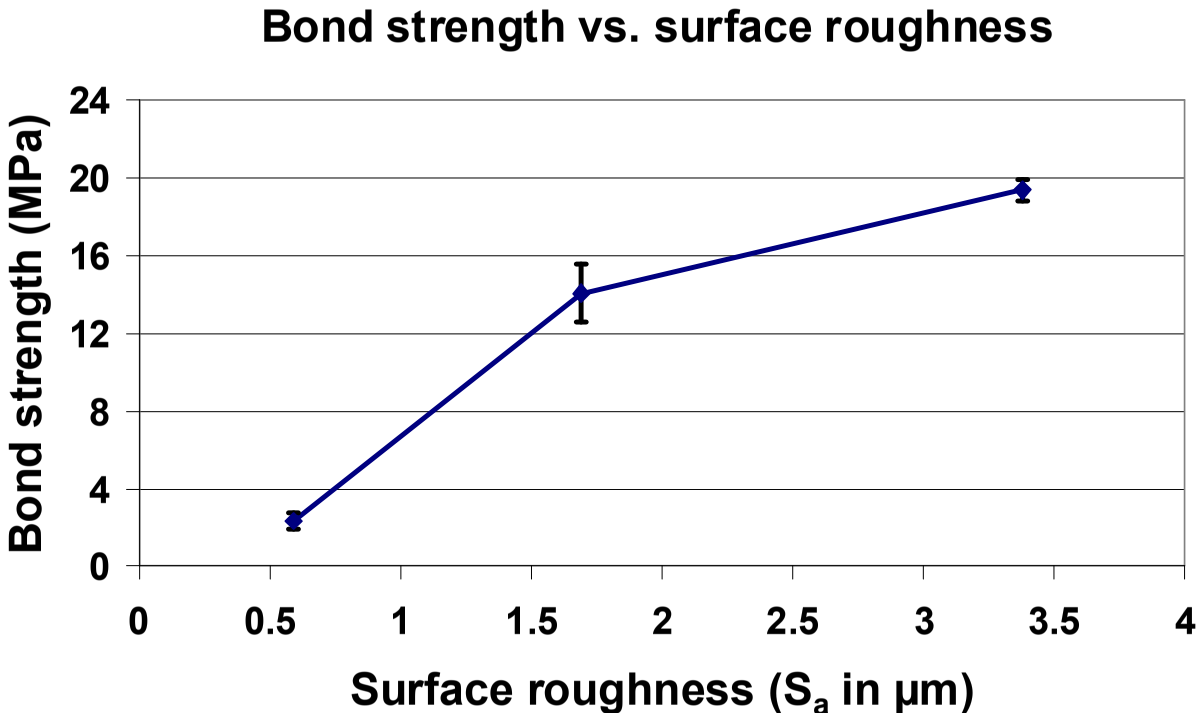
Effects of injection moulding parameters on bond strength

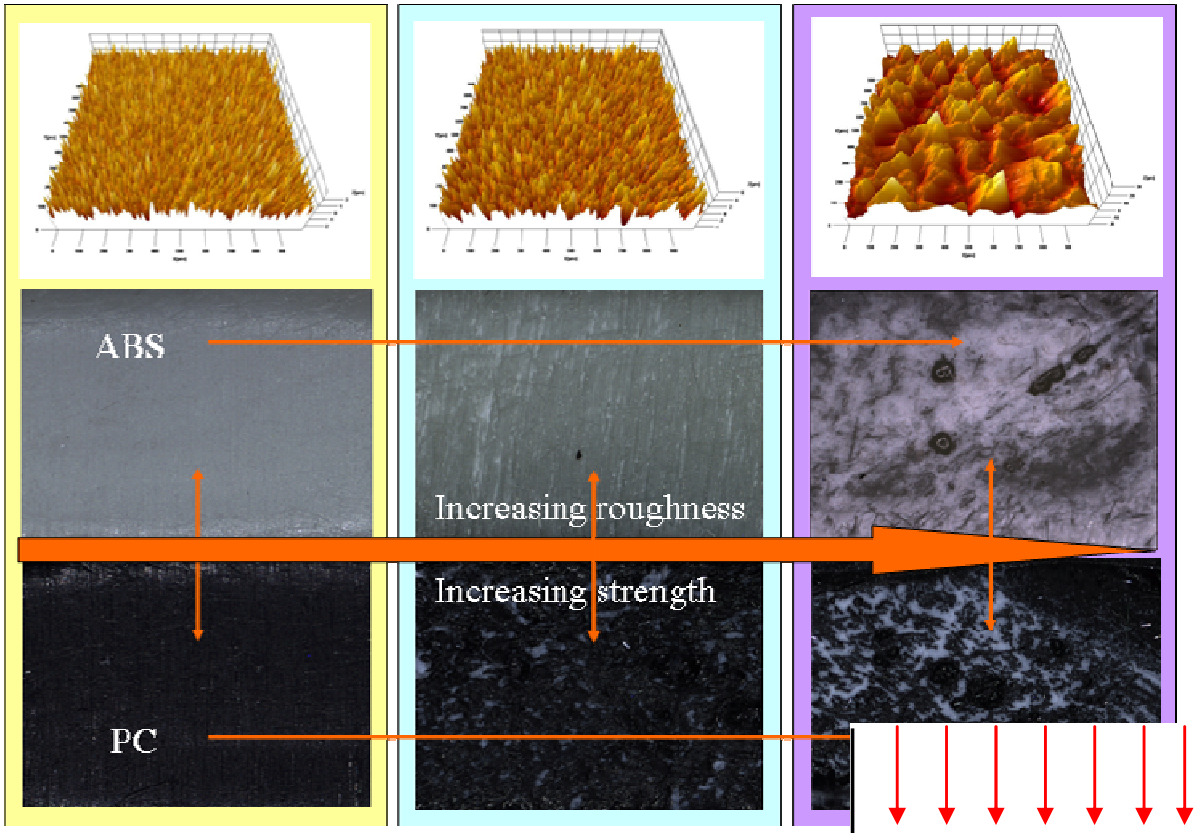
Comparative influence of injection moulding parameters on the bond strength



Effects of surface roughness





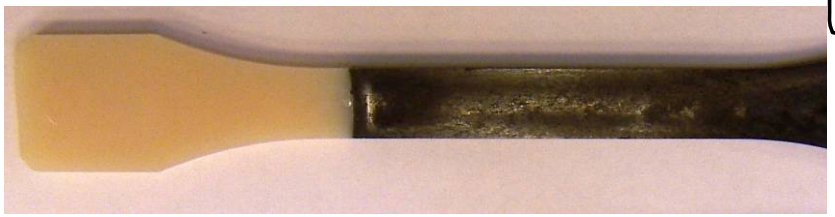


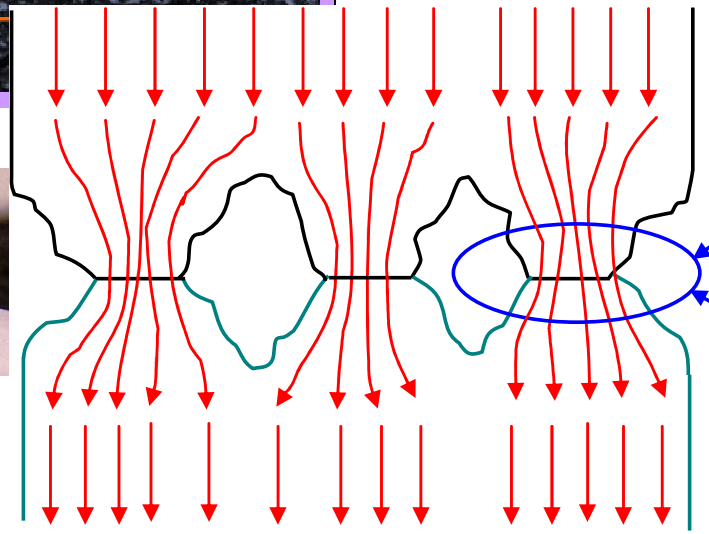
Effects of surface roughness

-Mechanical locking

-Increased area

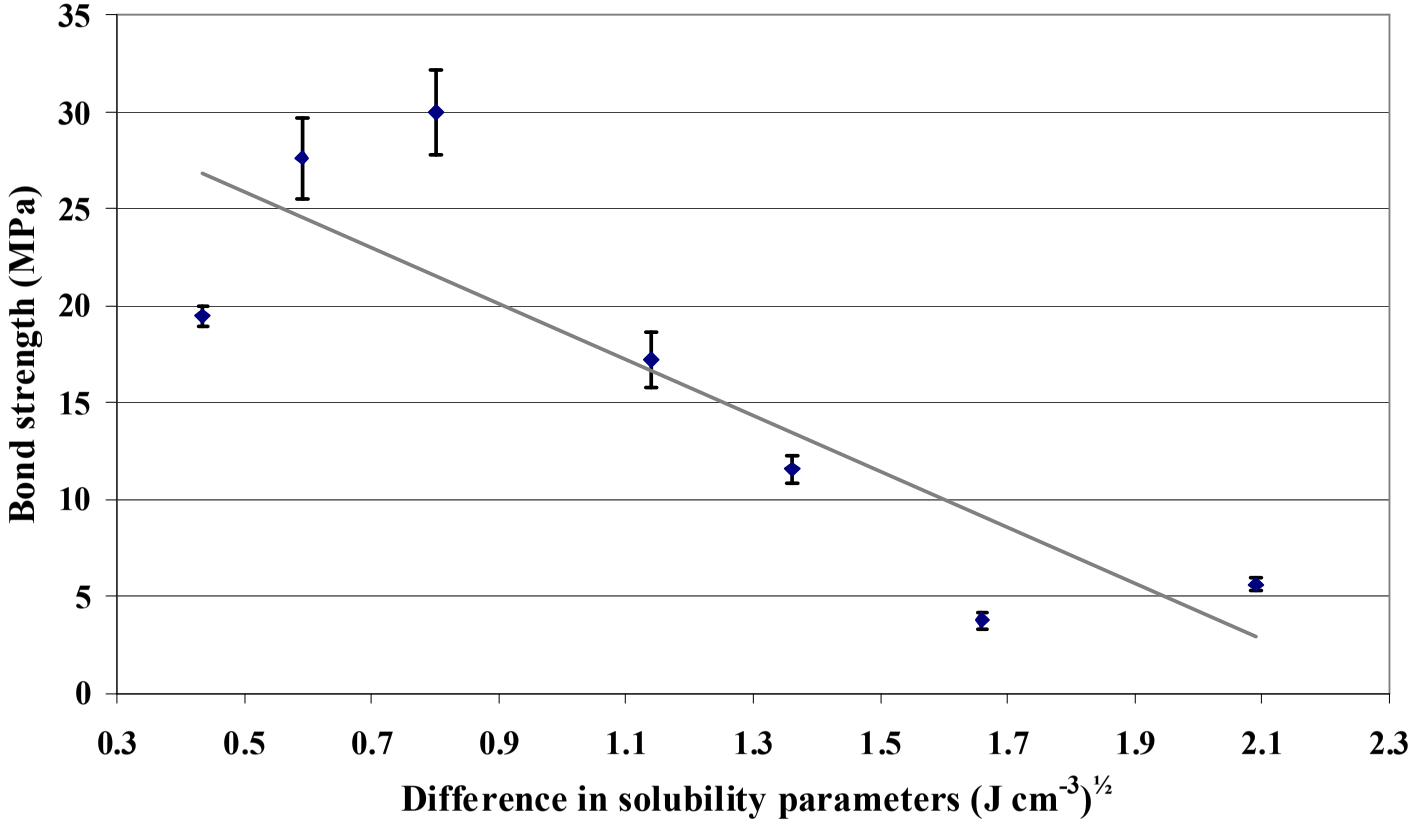
-Localized melting (high surface area to volume ratio)





Effect of solubility parameters on the bond strength

- Characteristic of a polymer used in predicting the solubility of that polymer in a solvent



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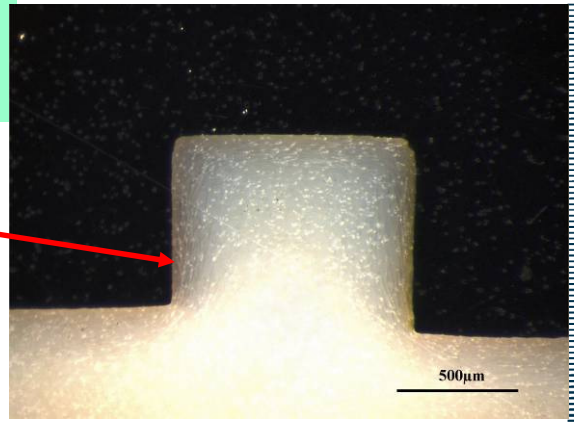
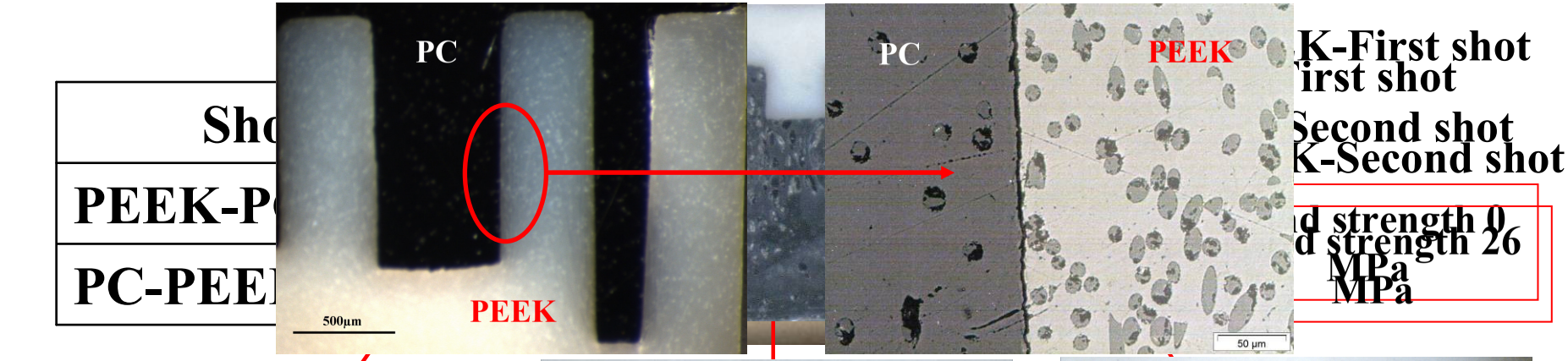
Micro MID

Functional requirement	Manufacturing process	Quality parameter
Material integration	2k micro moulding	Bond strength
		Interface
Conductivity	Electroless metallization	Selective metallization

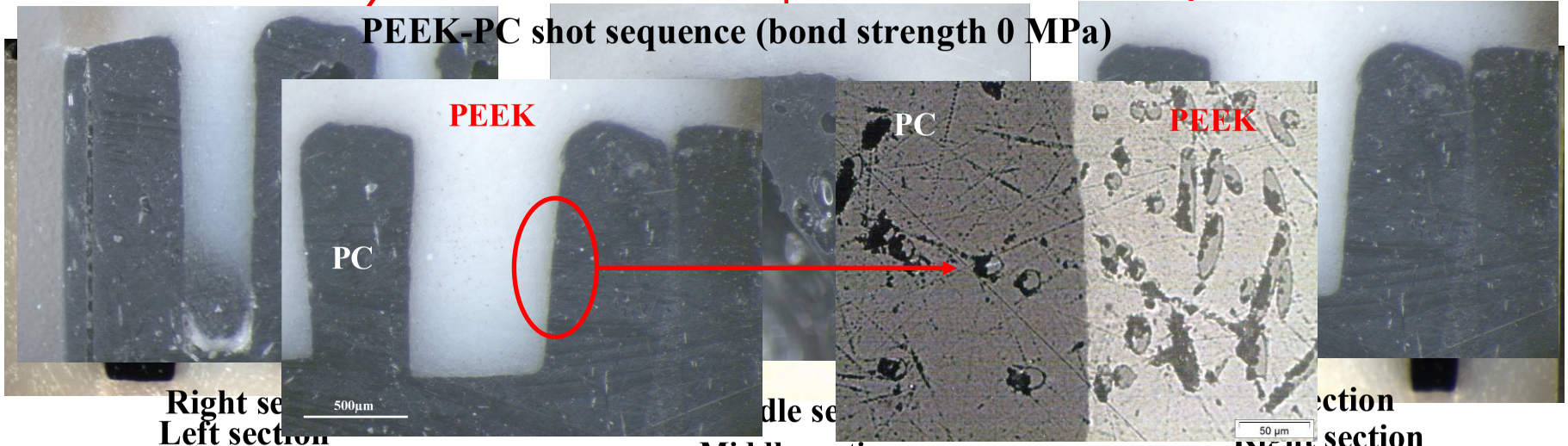
Demonstrator MID



Polymer-polymer bond strength and interface dilemma



PEEK-PC shot sequence (bond strength 0 MPa)

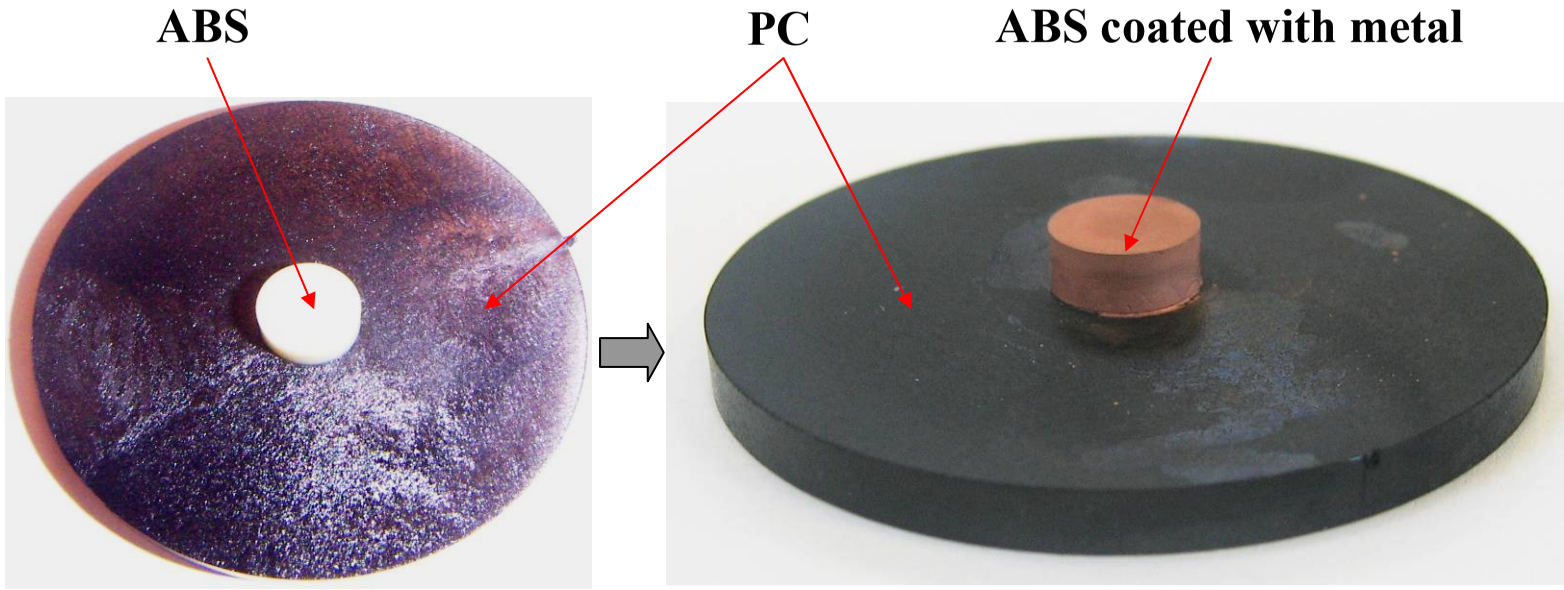


Left section
Middle section
section

PC-PEEK shot sequence (bond strength 26 MPa)

Selective metallization

Polymer pair	Metallized polymer
ABS-PC	ABS
PEI1000-Noryl GTX810	Noryl GTX810
PEEK- Noryl GTX810	Noryl GTX810

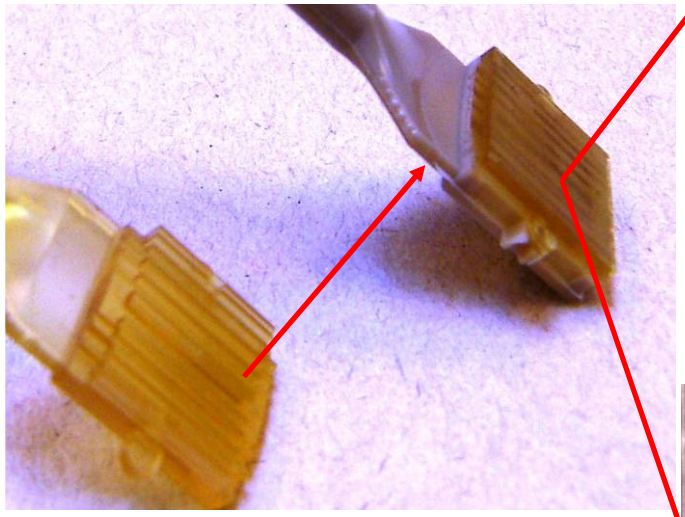


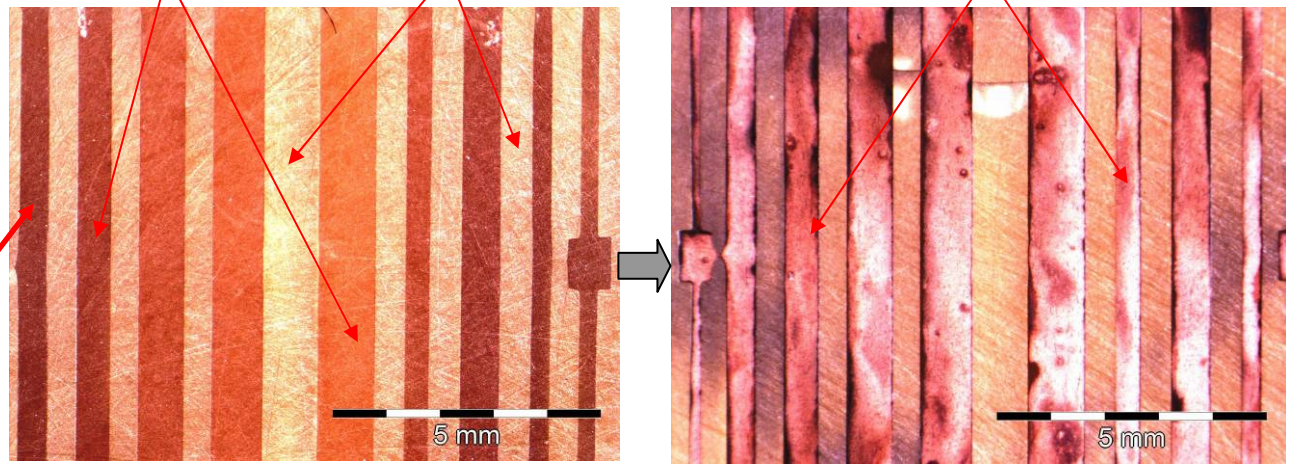
Before metallization

After metallization

PEI1000-Noryl GTX810

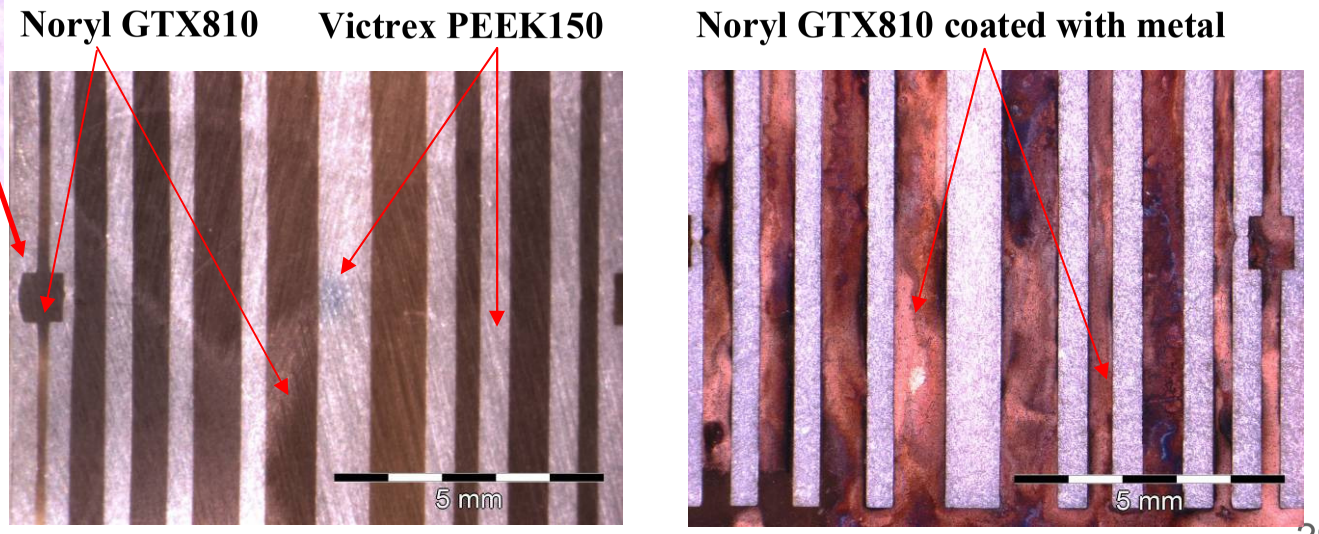
PEEK- Noryl GTX810





Before metallization

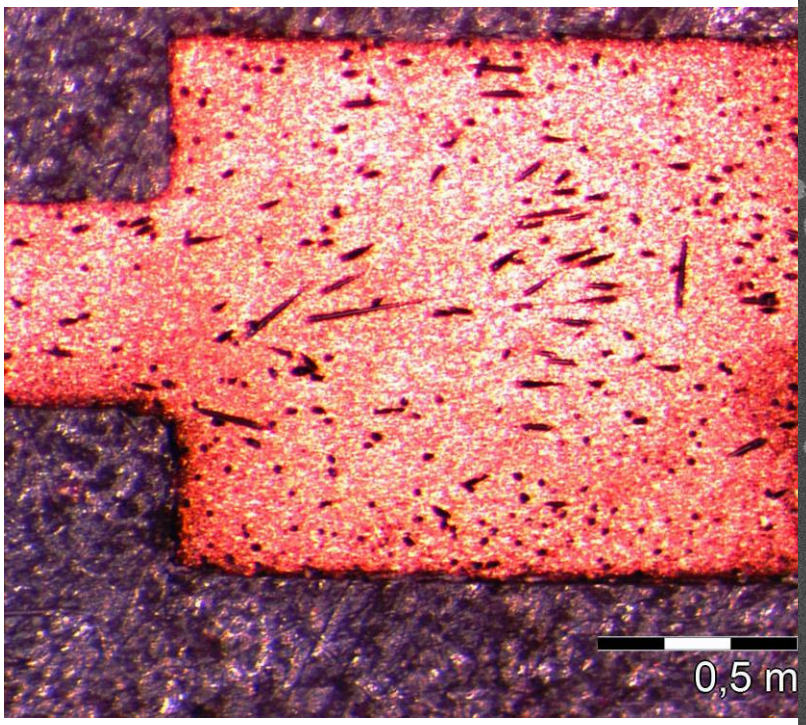
After metallization

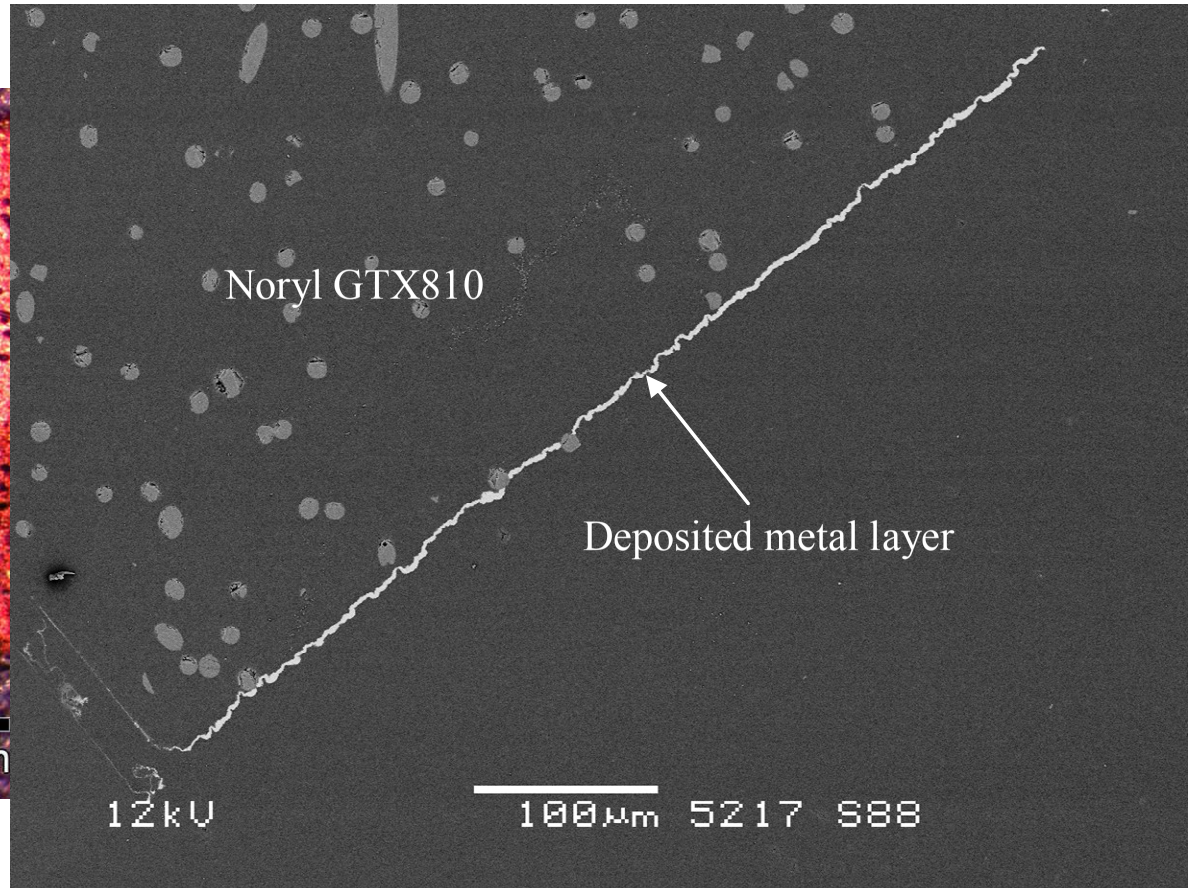


Before metallization

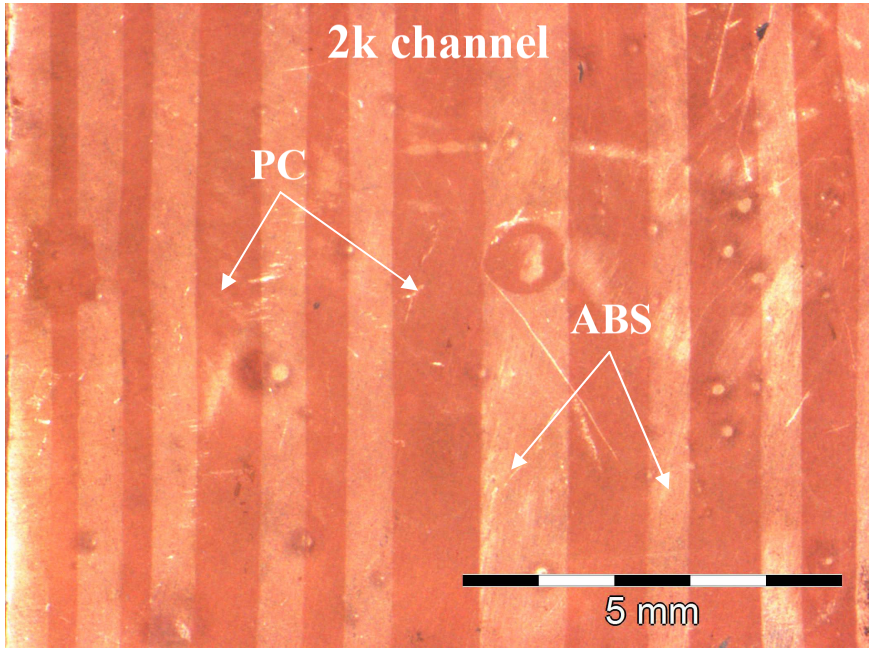
After metallization

Selective metallization

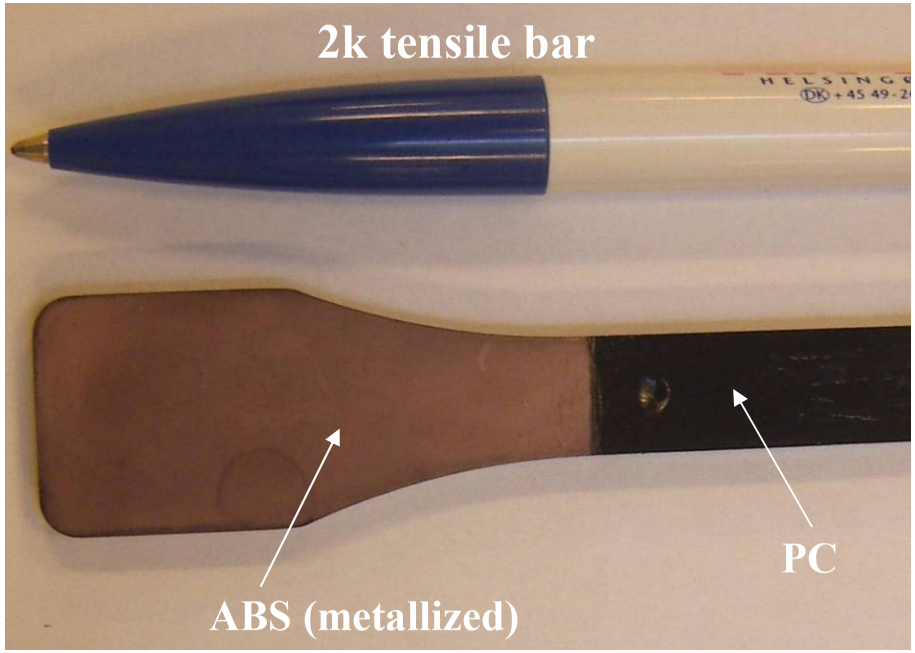




Difficulties in selective micro metallization

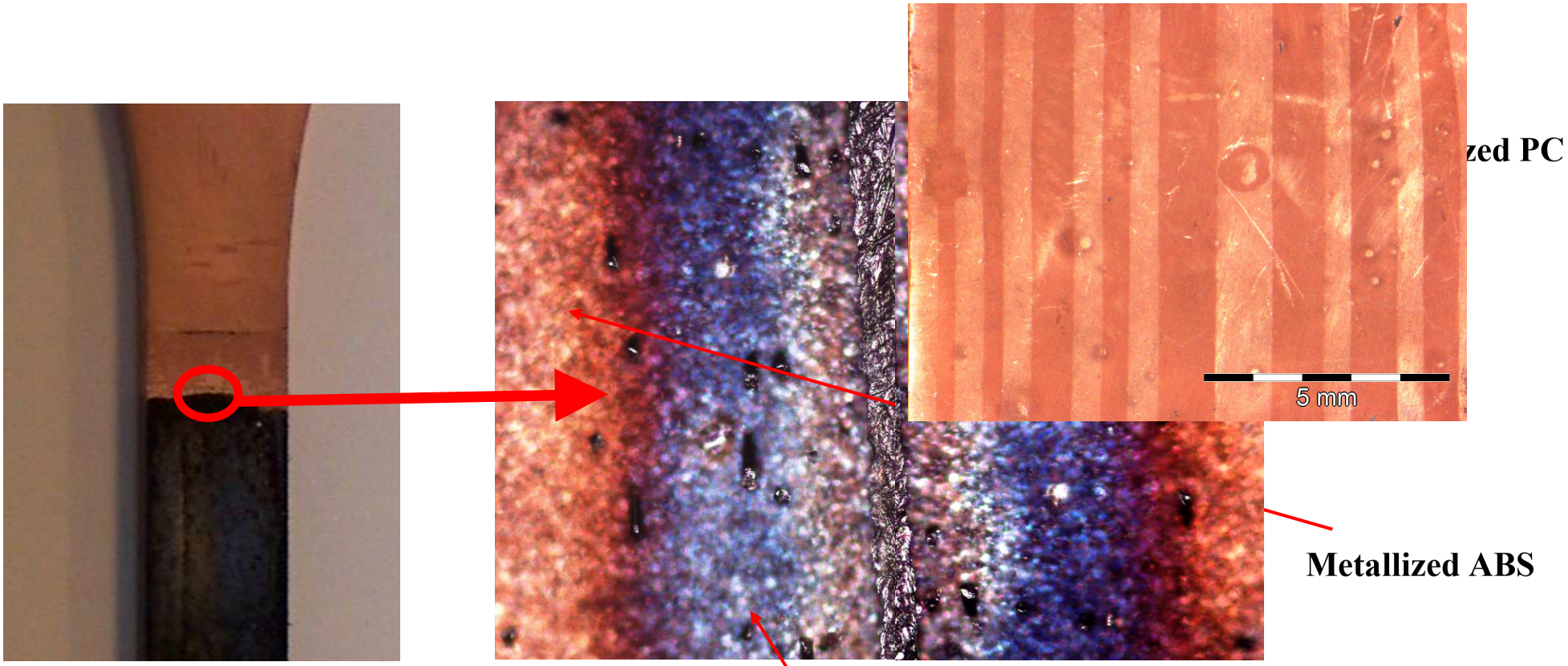


ABS-PC part after metallization



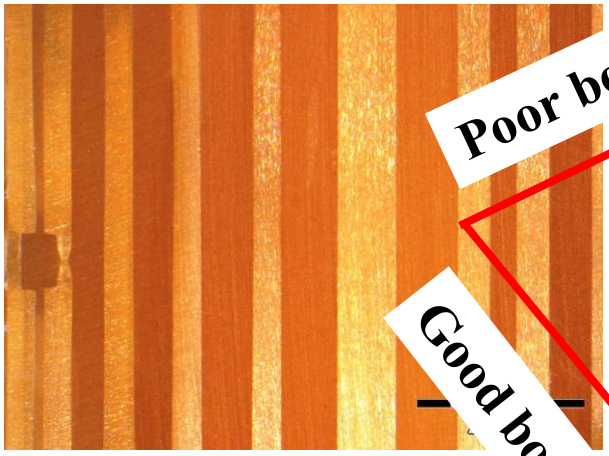
ABS-PC part after metallization

Intermediate zone of metallization

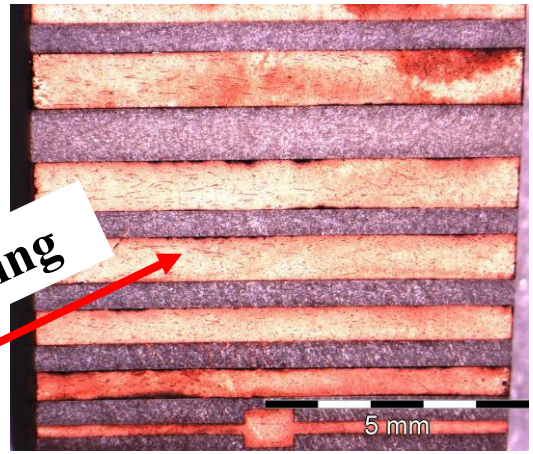


Interface quality and selective metallization

PEI1000-GTX 810



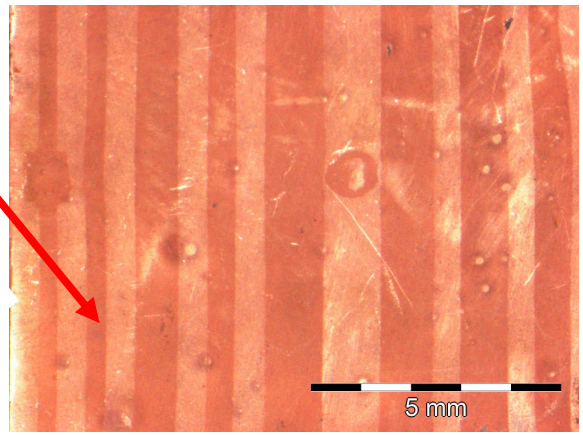
Poor bonding



-Polymer not mixing at the interface (bond strength 3 MPa)

-Selective metallization

Good bonding



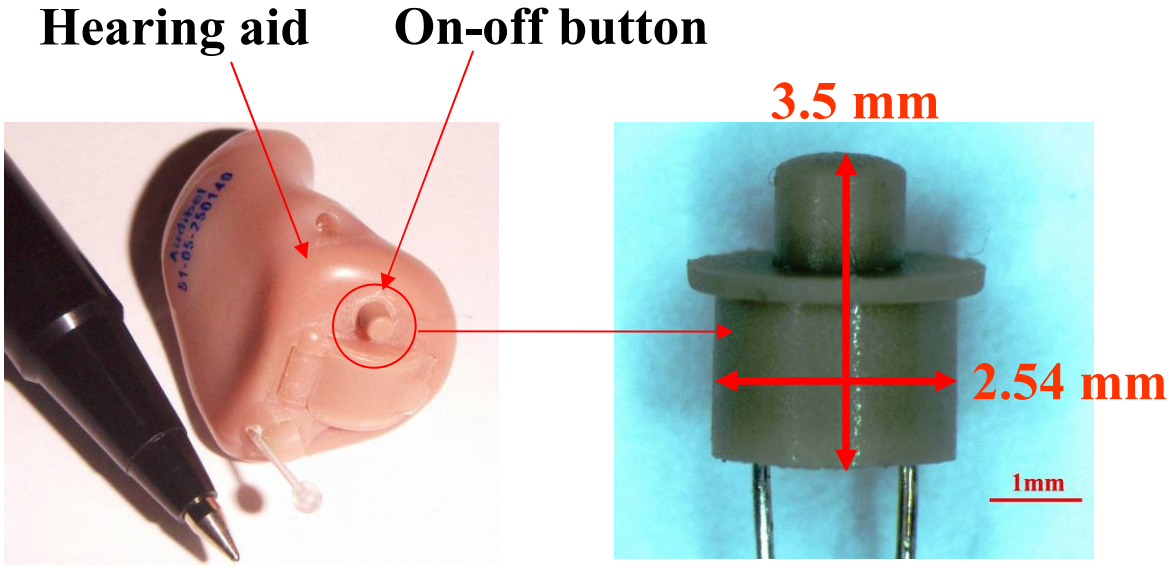
-Polymer mixing at the interface (bond strength 19 MPa)

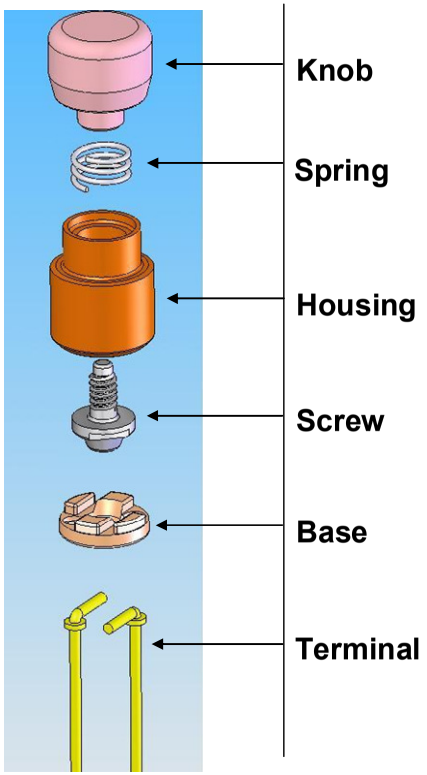
-Non-selective metallization

ABS-PC

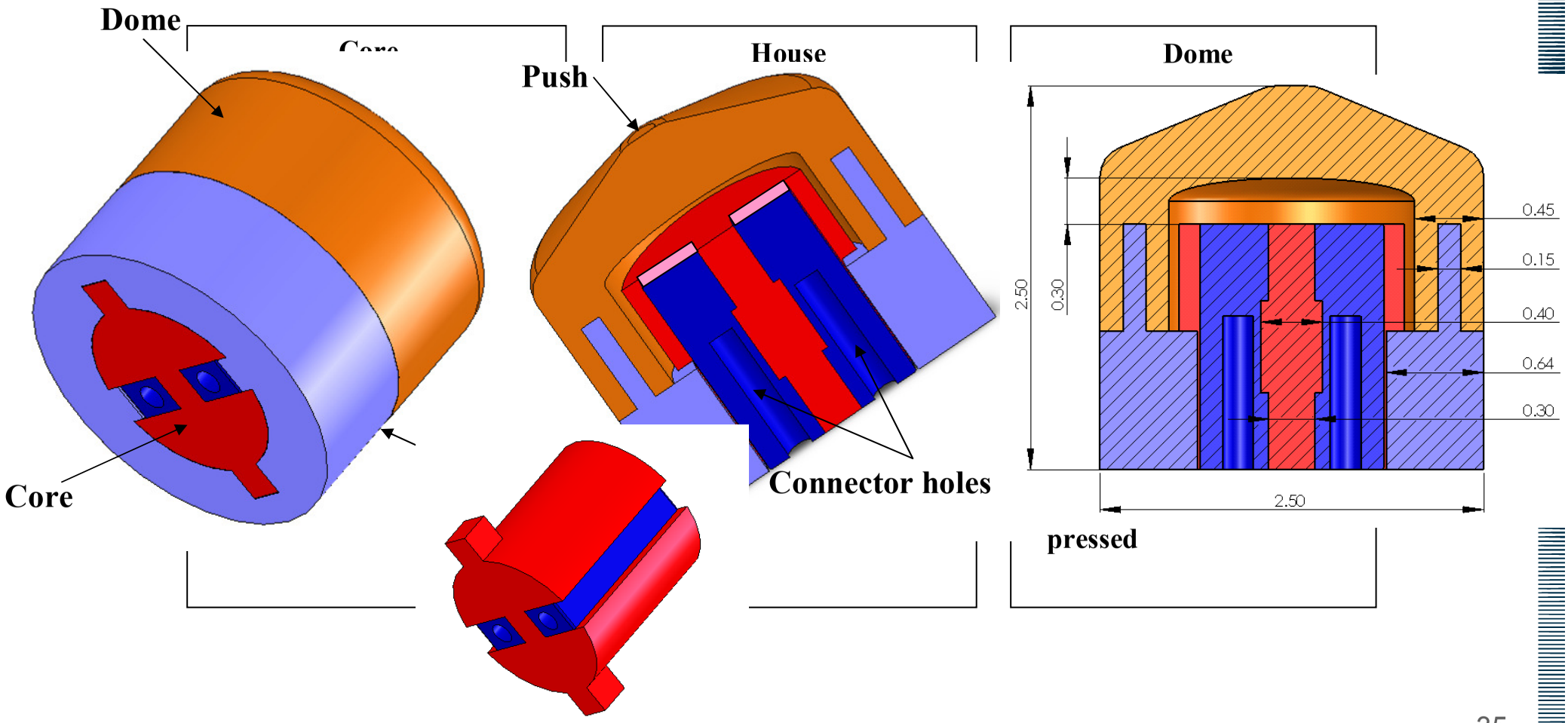
Demonstrator MID

- **On-off button used in hearing aid by Pulse ApS**

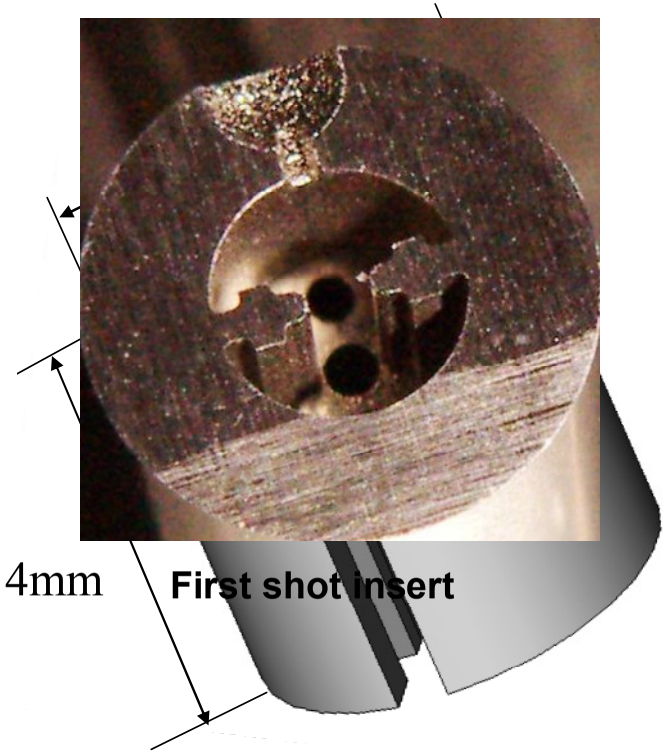




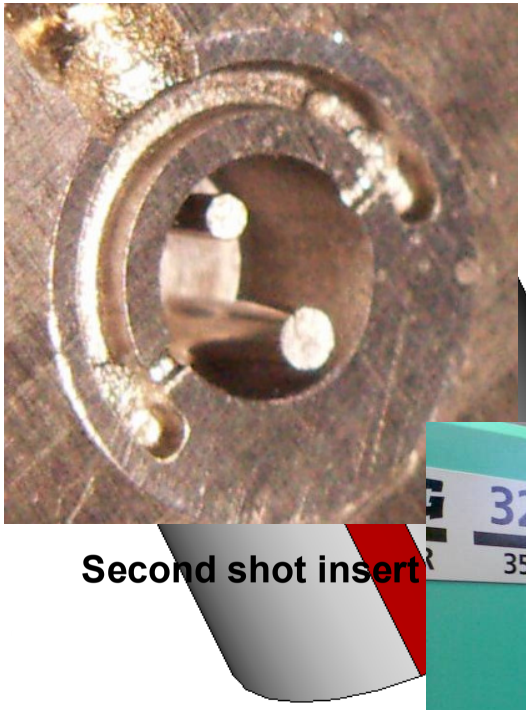
New concept of push button



Selected demonstrator geometry (push button core)



First shot part



Part after secon

Second shot

-Design

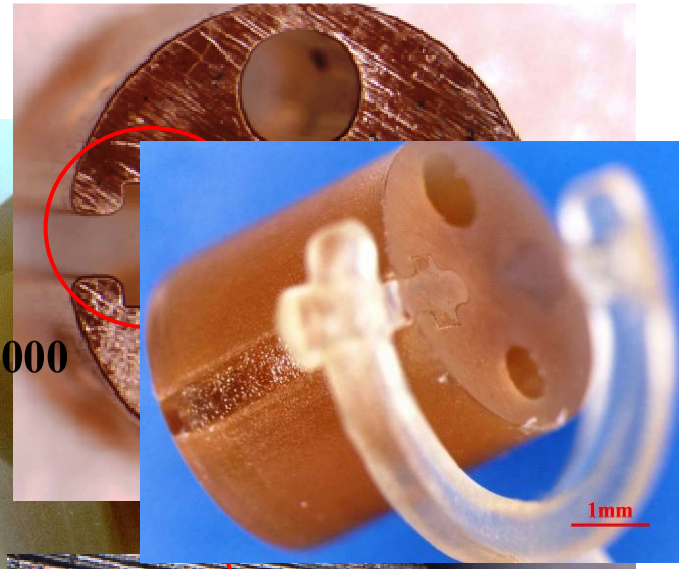
-Tooling

-Injection moulding

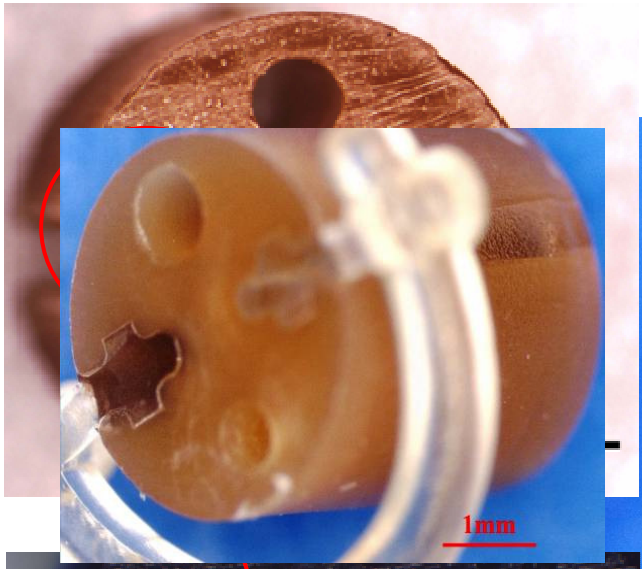
Injection moulding

Ultem PEI 1000

GTX 810-PEI1000

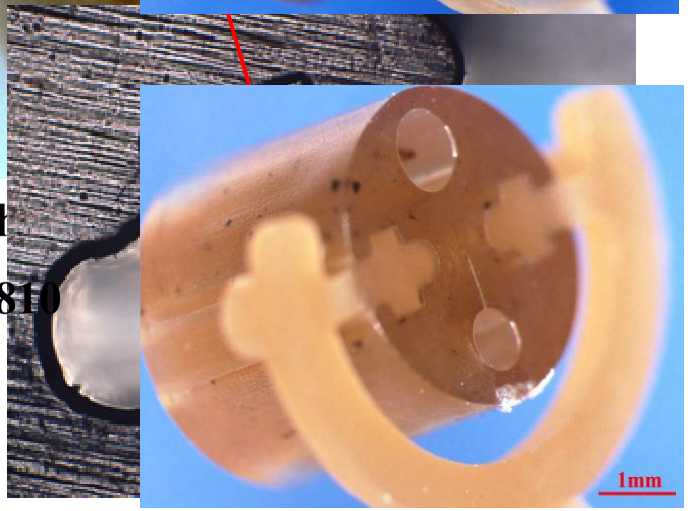


Noryl GTX 810

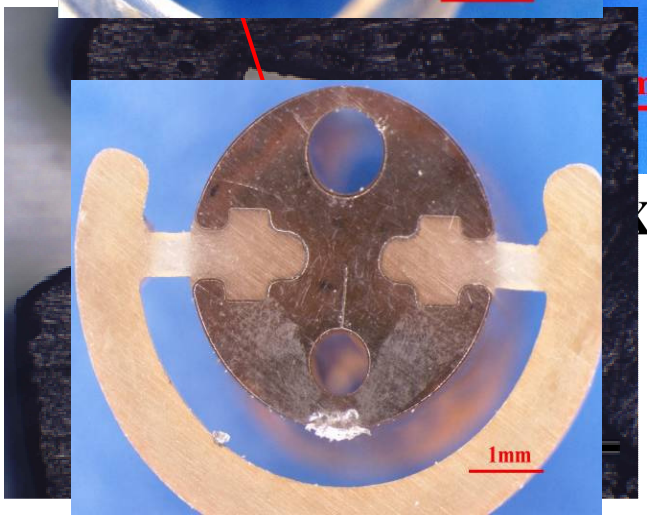


1st sh

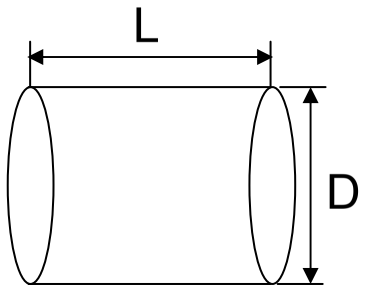
PEI1000-GTX810



X810



Metallization



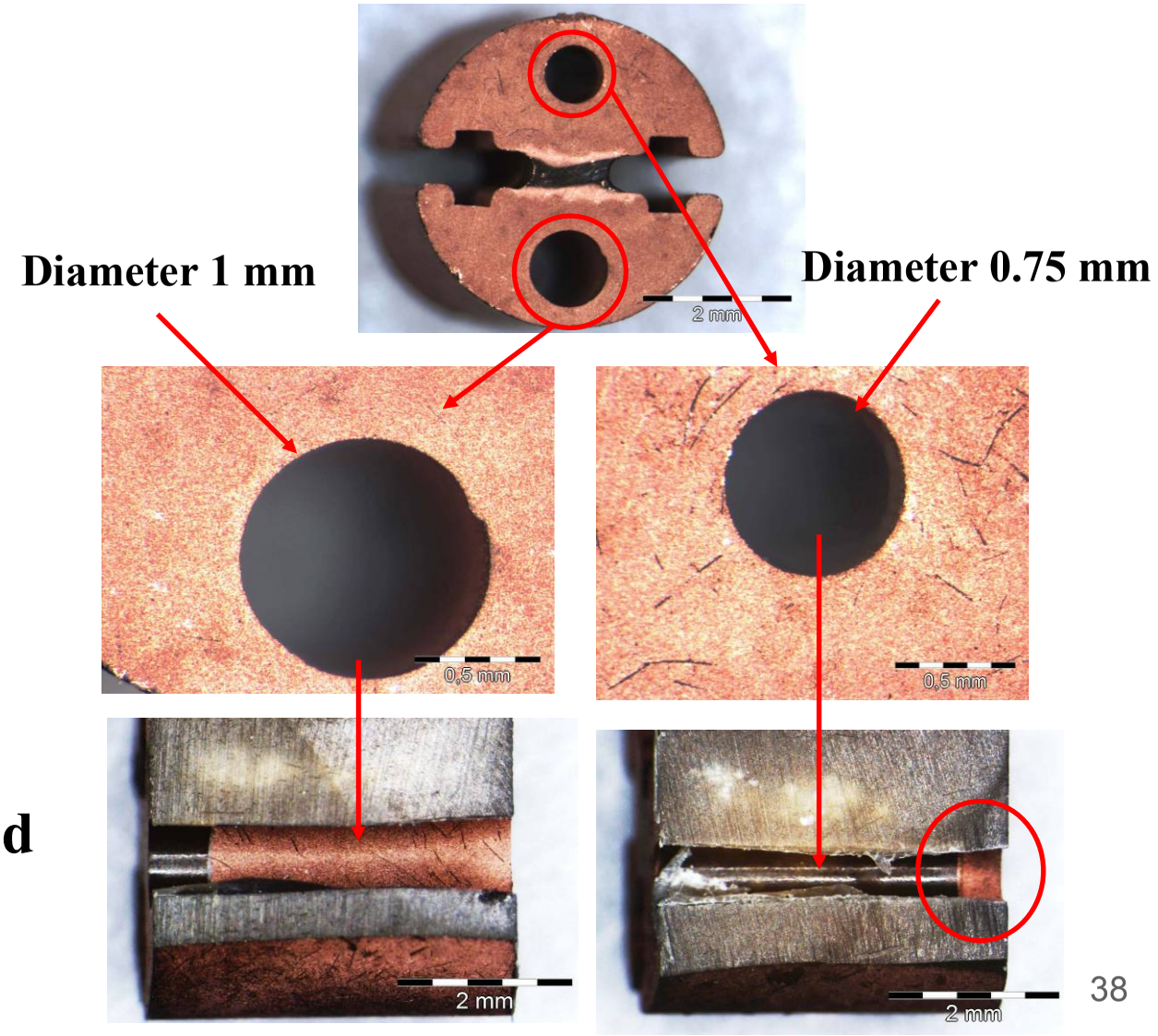
Through hole plating

-Trapped air and chemicals

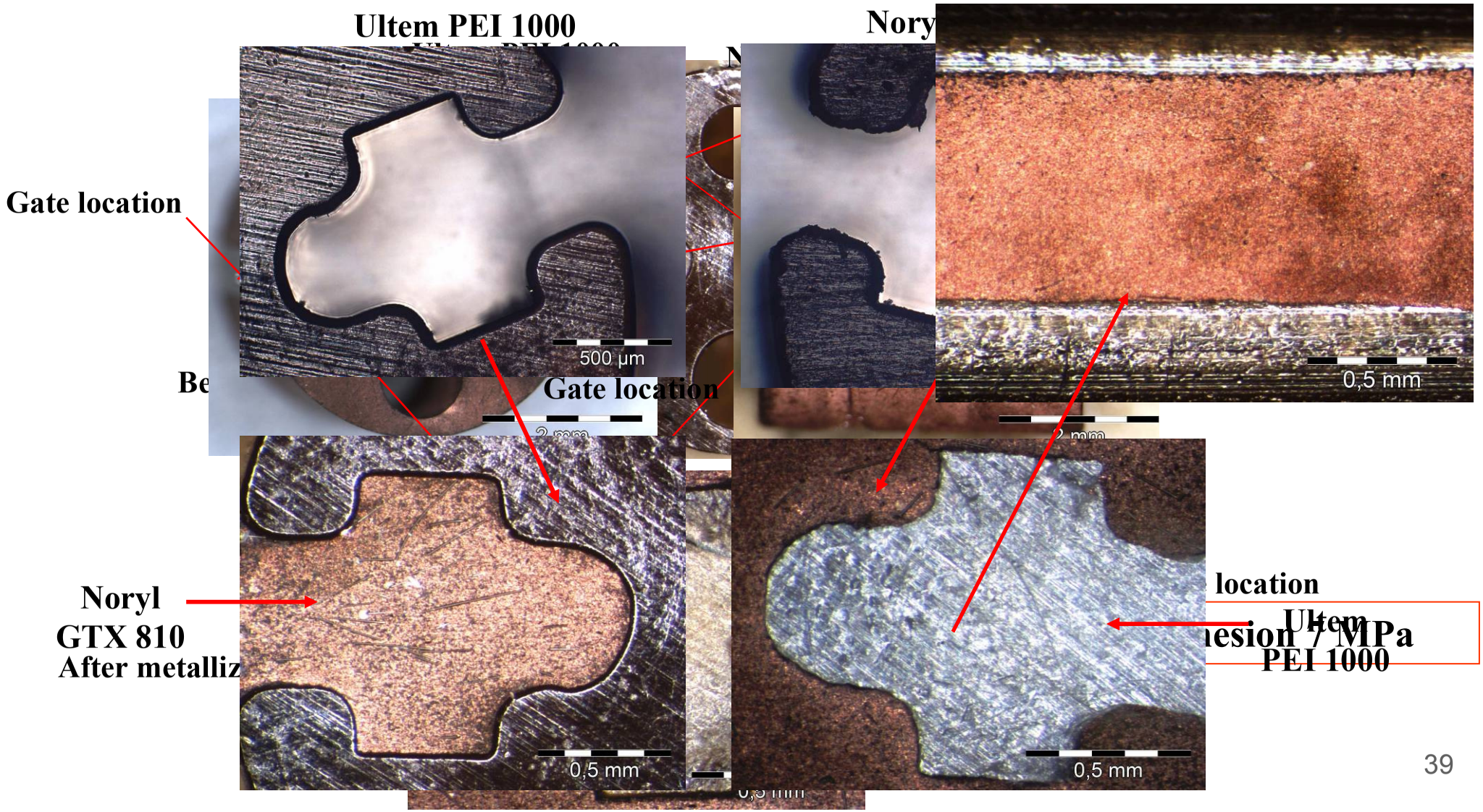
-Length/diameter ratio (L/D) is critical

-Optimization is required for higher L/D ratio

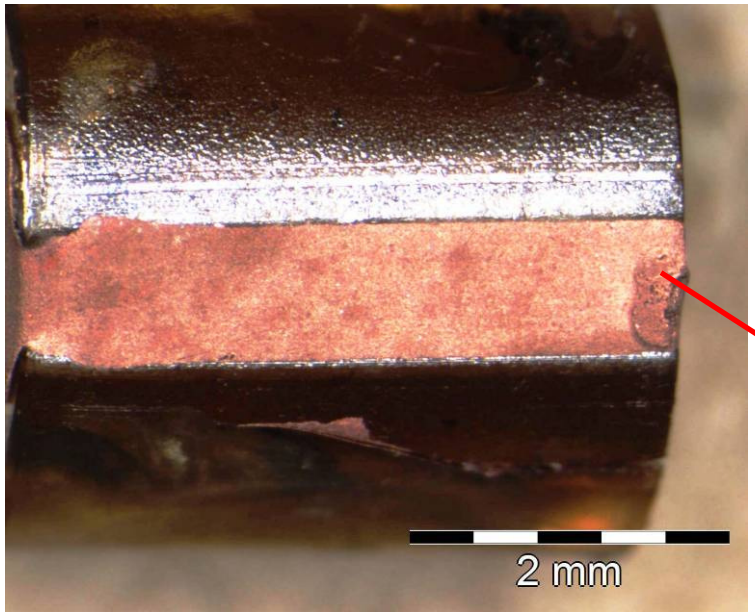
Noryl GTX810 1k part (Metallized)

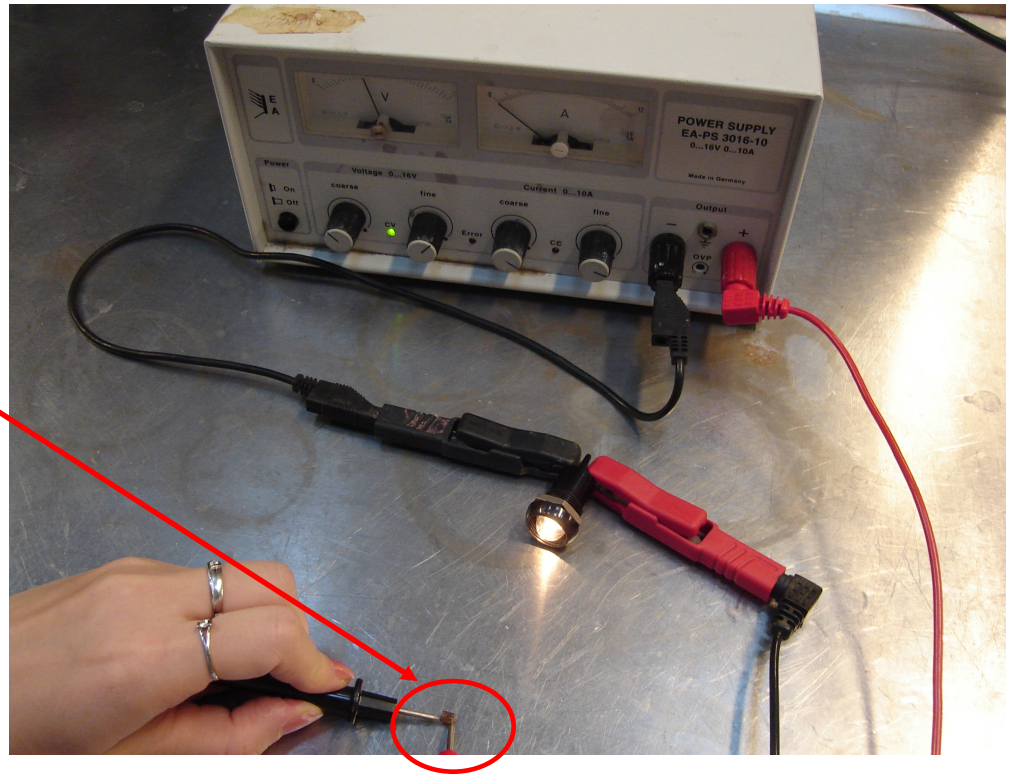


Selective metallization



Electrical testing





Summary and conclusion

1. New material pairs for 2k applications and also for MID applications. LCP, POM proved unsuitable for 2k micro moulding and micro MIDs

2. Important factors for bond strength: Injection parameters, interface temperature, material shot sequence, substrate surface roughness, environmental conditions

3. Polymer-polymer interface study, effects of various parameters on the interface, relation between the bond strength and interface of two polymers

Summary and conclusion

4. **Several new material pairs for selective metallization were identified. Factors affecting the metallization quality of plastic parts investigated**

5. **Demonstrator MID fabricated with the knowledge gained from the project proved its feasibility for industrial applications**

Thank you for your attention