

**U.M.F. "Carol Davila", Bucharest
Faculty of Dental Medicine**



**Dental Technology and Dental Materials
Department**

IPS CLASSIC ADHESION TO NON-NOBLE ALLOYS

Authors:

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- 1. Comparative analysis of metal-ceramics interface for Ni-Cr and Co-Cr alloys;**

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- 3. F.E.M. (finite elements modeling) of physical test**

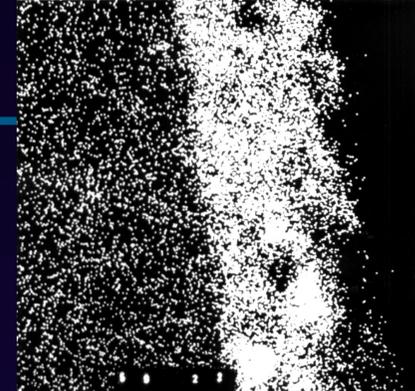
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- 2. Physical testing of metal-ceramics bond strength - CAM_T ;**
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ARGUMENT



METAL-CERAMICS INTERFACE ANALYSIS (before mechanical tests)



- ***Which are the elements (from alloys and from ceramics) participating to chemical bond?***
- ***Level of inter-atomic diffusion?***

Alloys came into study

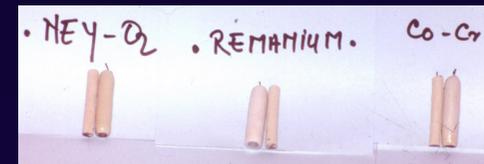
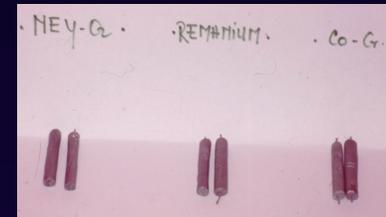


			Composition [%]				
	Name	color	Ni	Co	Cr	Mo	Other metals
1	Remanium CS (Germany)	alb	61	-	26	11	2
2	NEY Q II (USA)	alb	77	-	11.5	4	8.5
3	Co-Cr Hungary	alb	-	69	24	4	3

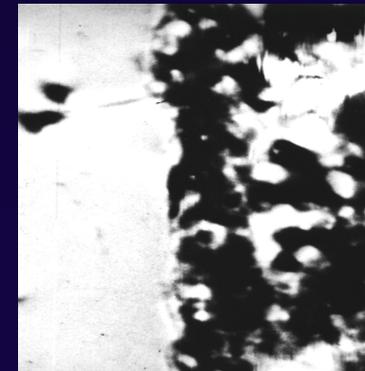
Probe preparation

Craig, O'Brien, Phillips

- Classical probe preparation:



- Interface structure analysis:

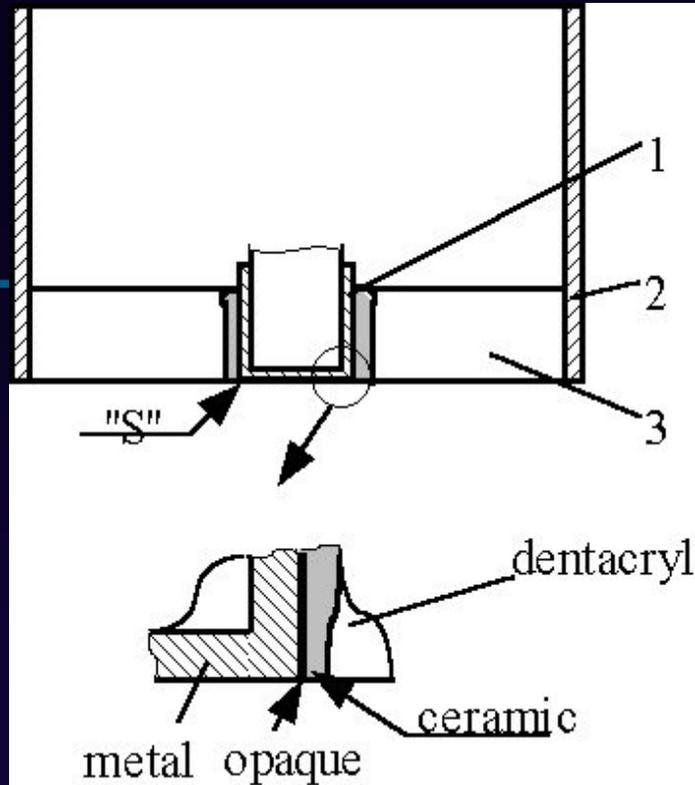


New sample's design



Firing Phases	Final temperature [°C]	Heat speed [°C/min]	Firing times [min]	Final temperature maintaining time [min]	Vacuum starting temperature [°C]
Oxidation	1020	140	0,3	-	-
Opaquer	980	80	6	1	590
Layer I	930	60	4	1	590
Layer II	920	60	4	1	590

Probe preparation for the analysis



1. **Metal-ceramics cap;**
2. **Sustaining ring;**
3. **Acrylic resin (Dentacryl).**



Probe preparation for the analysis

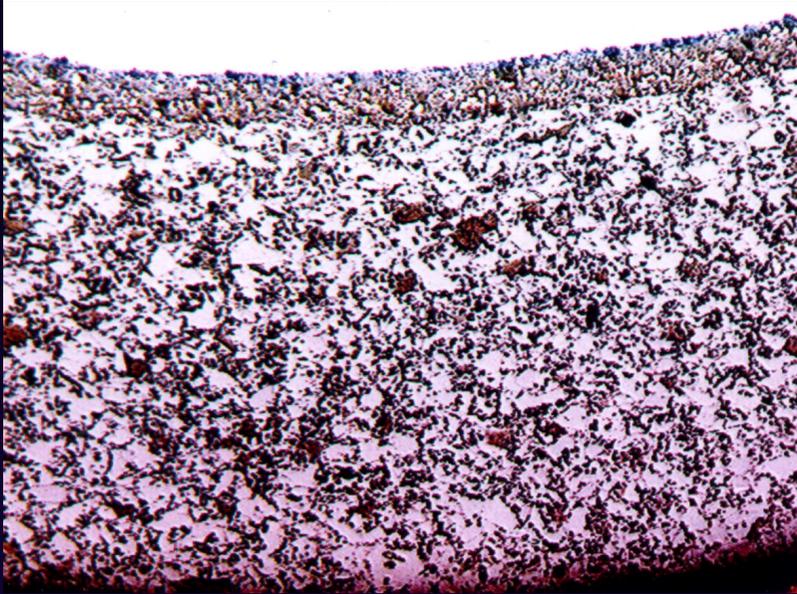
- *Mechanical preparation*
- *Chemical preparation*
(HNO_3 -3,5ml, HF-1ml, H_2O – 44ml).



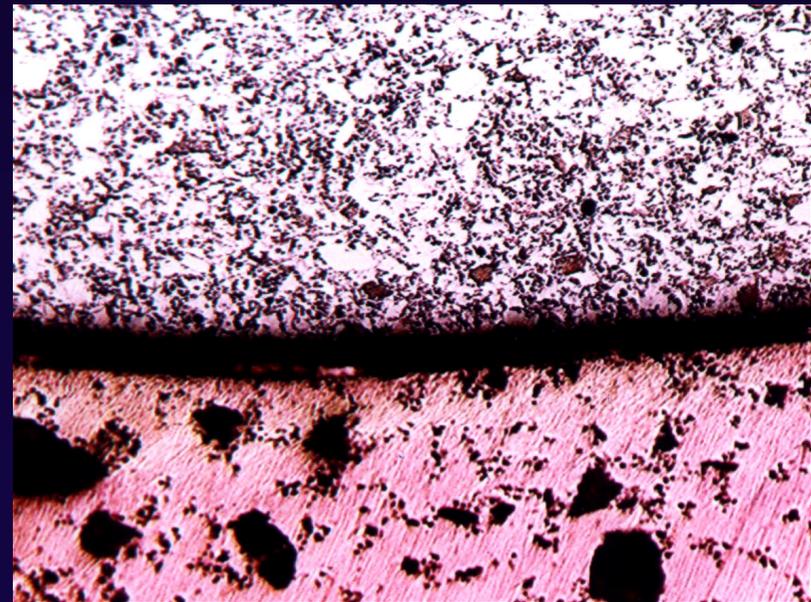
Probes analysis

- **Optical microscopy**
- **SEM – Rx investigation**

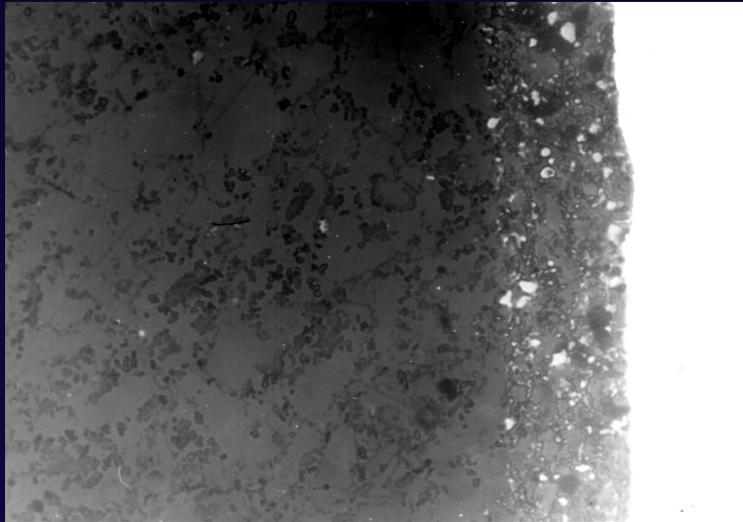
Optical microscopy (Co-Cr alloy)



- **Continuous SiO_2 along the metal-ceramics interface.**



Optical microscopy (Ni-Cr alloy)



- **Interface quality**
- **Avoiding sample damages**

SEM-Rx analysis

Elements diffusion phenomena:

- **From ceramics (Si, Al, Co) into Ni-Cr and Co-Cr alloys;**
- **From alloys into ceramics.**

SEM-Rx results

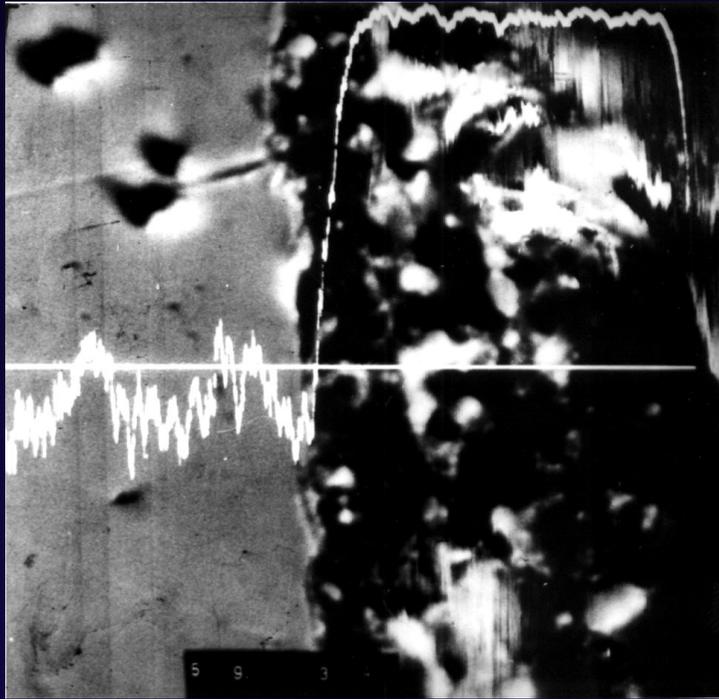


Rx map: Si

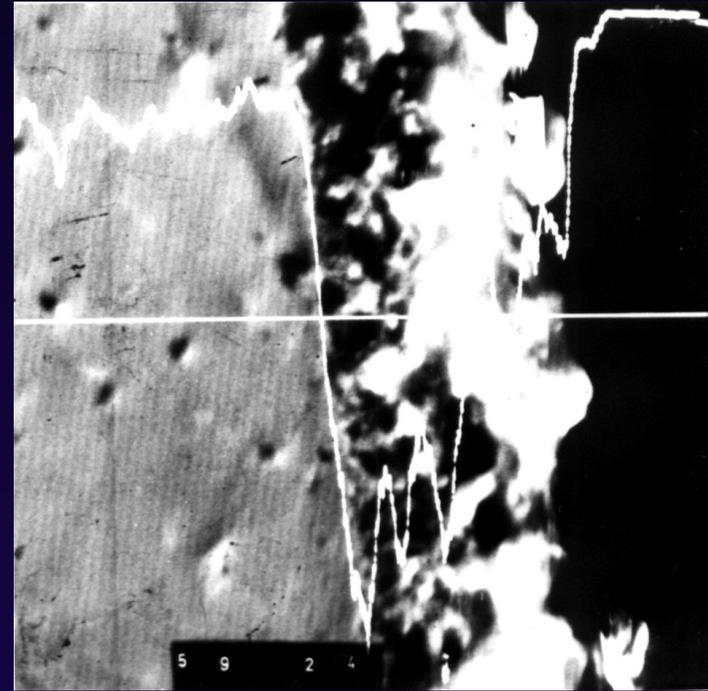


Rx map: Co

SEM-Rx results

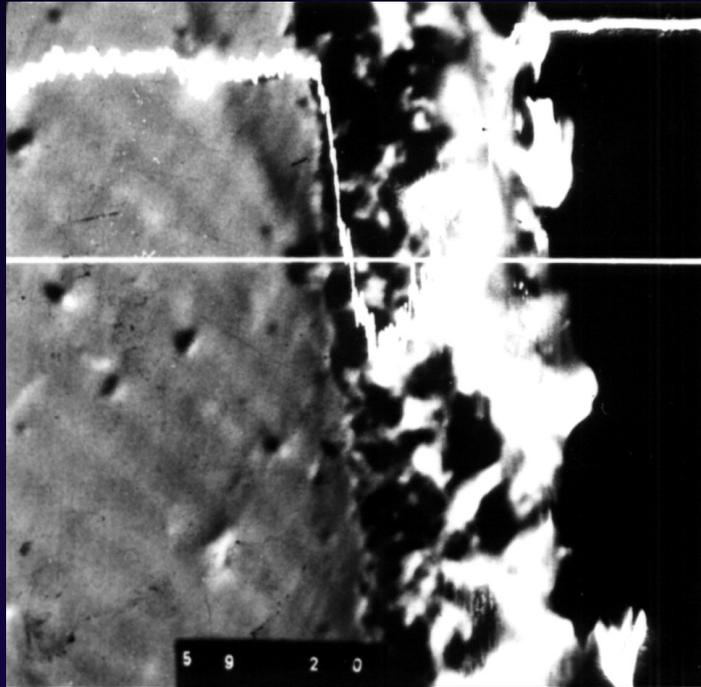


**Secondary electrons:
Co toward plated ceramics**

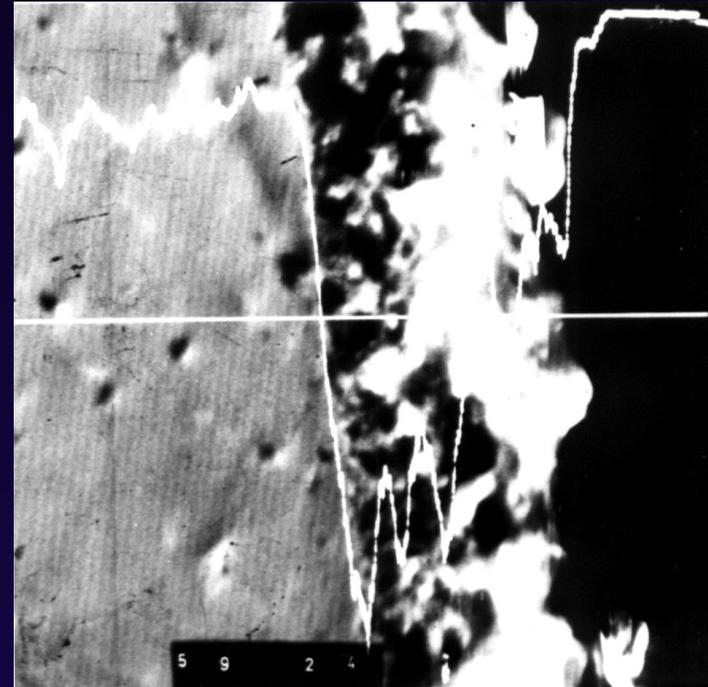


**Secondary electrons:
Al toward Co-Cr alloy**

SEM-Rx results



**Secondary electrons:
Si toward Co-Cr alloy**



**Secondary electrons:
Al toward Co-Cr alloy**

SEM-Rx analysis conclusions

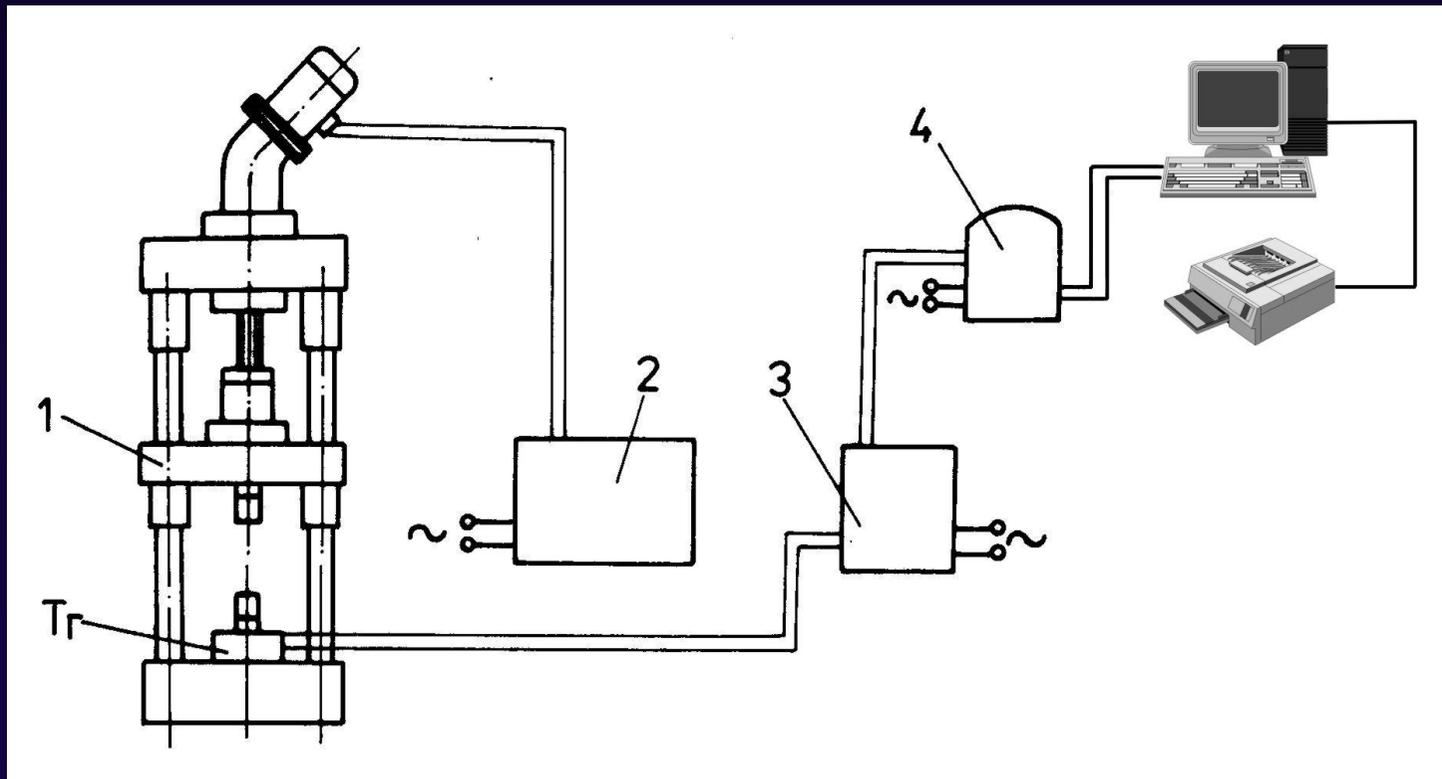


- **Diffusion phenomena is bidirectional;**
- **Ni-Cr alloy diffusion >>> Co-Cr alloy diffusion**
- **Diffusion processes are PROBABLY related to bond strength**

CAM_T – COMPUTER ASISTED MECHANICAL TESTING SYSTEM



CAM_T PROJECT



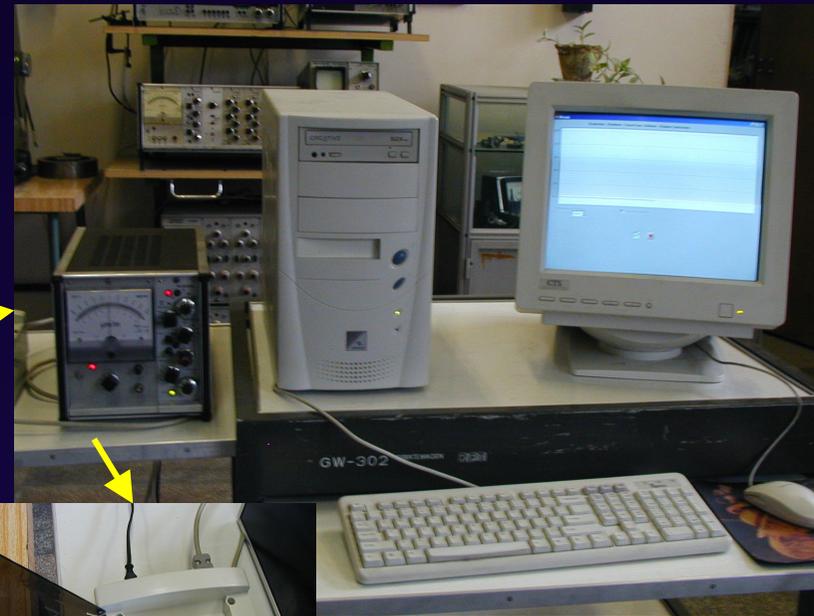
CAM_T SYSTEM



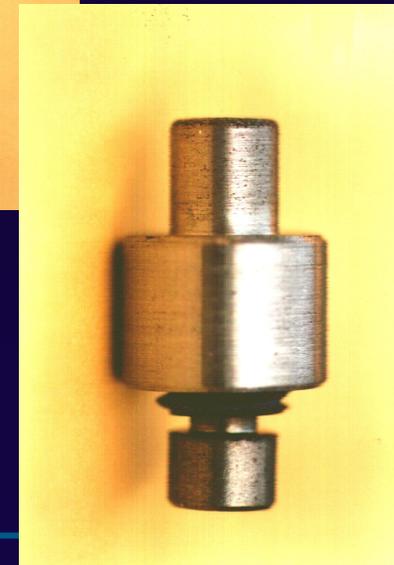
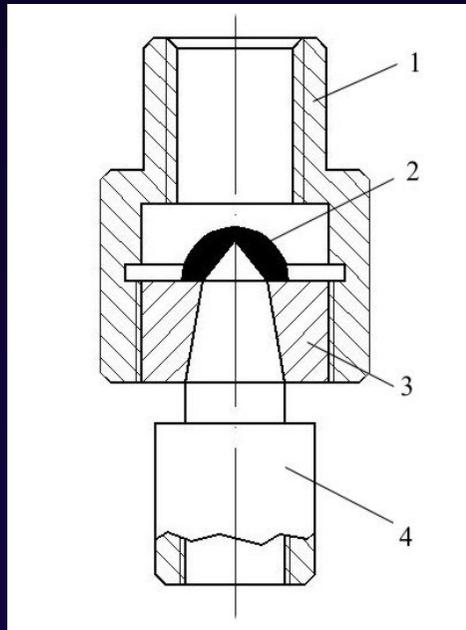
CAM_T COMPONENTS



CAM_T FUNCTION PRINCIPLE



EXPERIMENTAL METHOD



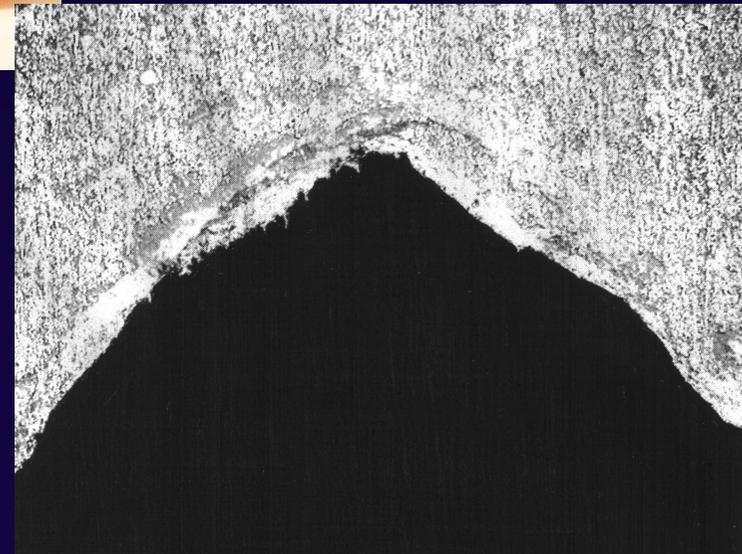
- *Probes design*
- *~ Sced și McLean*
- *$S = 8,95 \text{ mm}^2$*

PHYSICAL TEST RESULTS

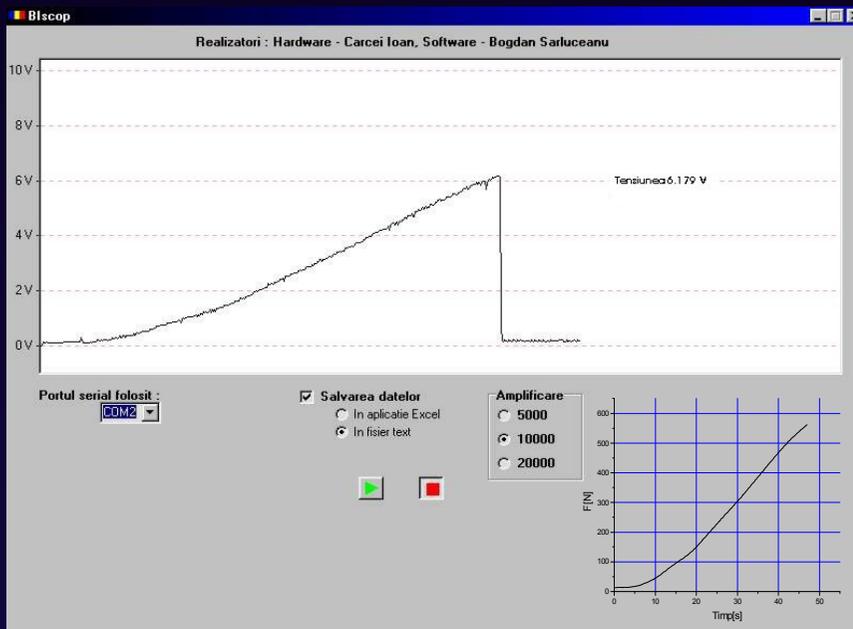
Probe	Metal surface	Alloy	Firing steps	Tension strenght		Notes
				F_r [N]	σ_r [MPa]	
I	Polished	NEY Q. II	a) <u>Oxidation</u> - Raising temperature 10 min. to 1020°C - maintaining 3 min. - cooling 7 min.	412	46	Fracture through metal oxides-ceramics
II	Sandbasted	NEY Q. II	b) <u>Firing opaquer IVOCLAR</u> - Raising temperature to 980°C - maintaining 1 min. - cooling 7 min.	561	62,7	Cohesive fracture through ceramics
III	Sandblasted	REMANIUM C.S.	c) <u>Firing IVOCLAR ceramics mass</u> - Raising temperature to 930°C - maintaining 1 min. - cooling 7 min.	496	55,4	Cohesive ceramics fracture COMBINED with fracture through metal oxides-ceramics



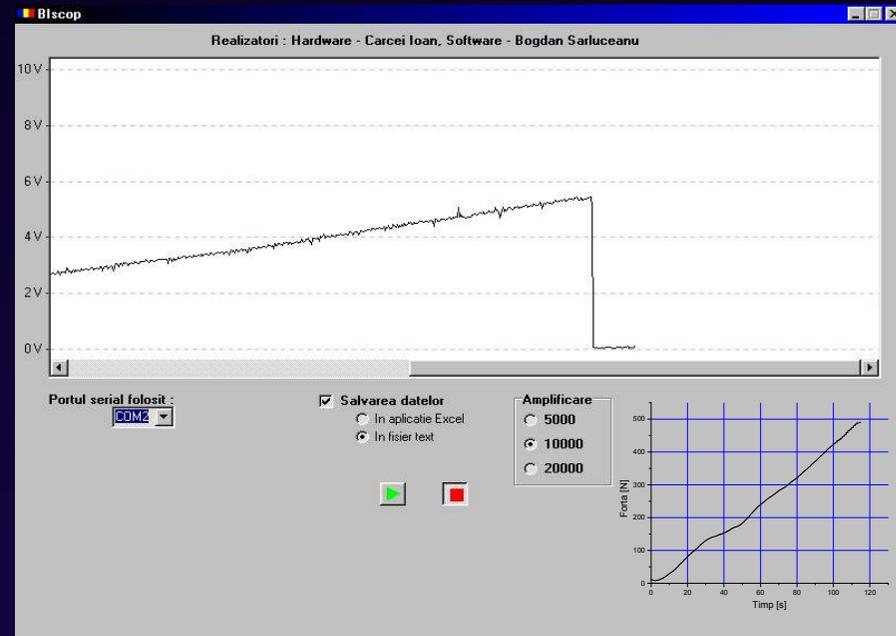
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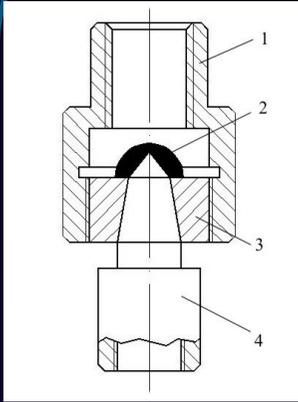


NEY Q. II



REMANIUM C.S.

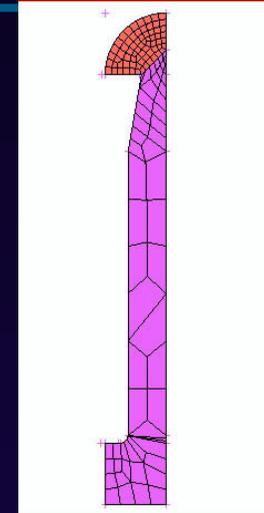
CAM_T v.s. FEM



PHYSICAL EXPERIMENT
- Monitoring physical parameters entering in experiment

FINITE ELEMENTS MODELING
*- Mathematical model development
- Numerical simulation
- Results interpretation and correlation with physical experiment results*

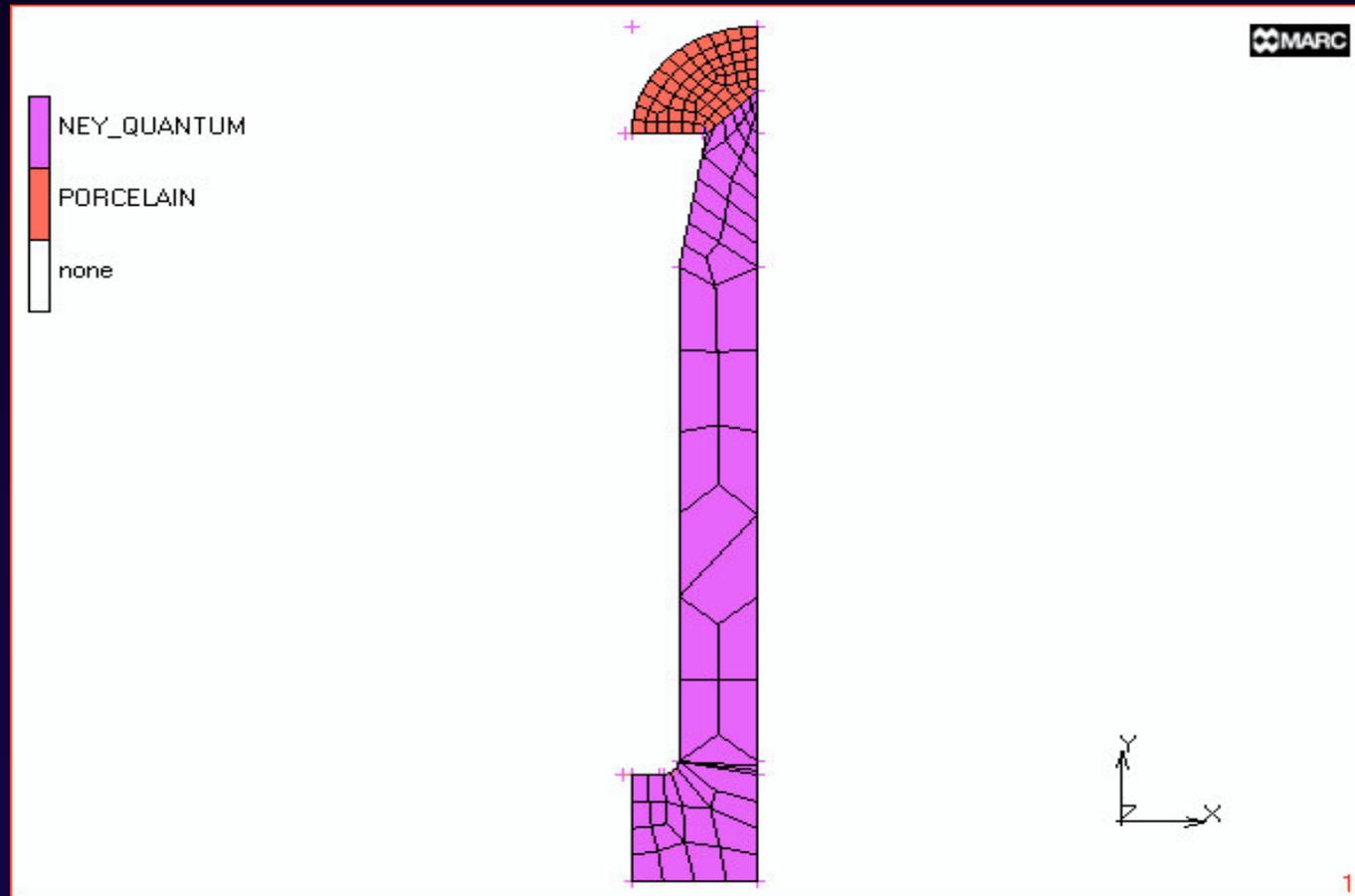
EQUIVALENT



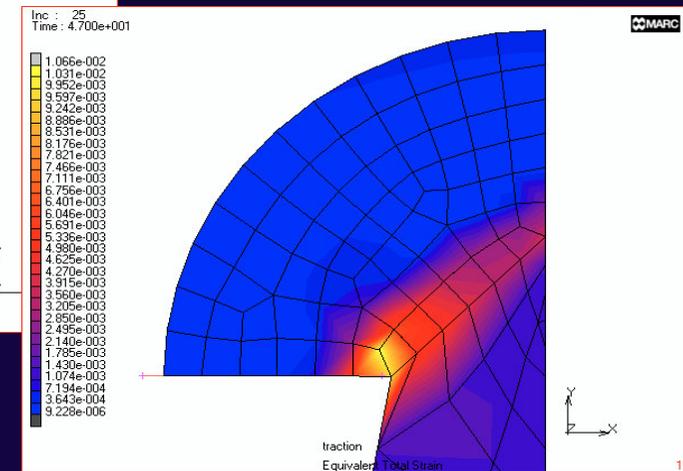
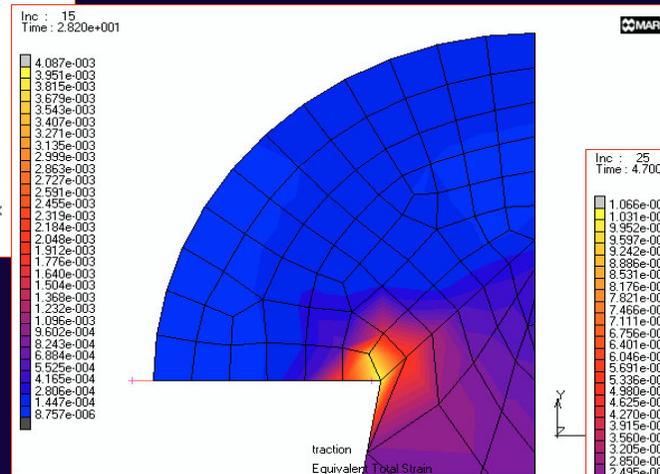
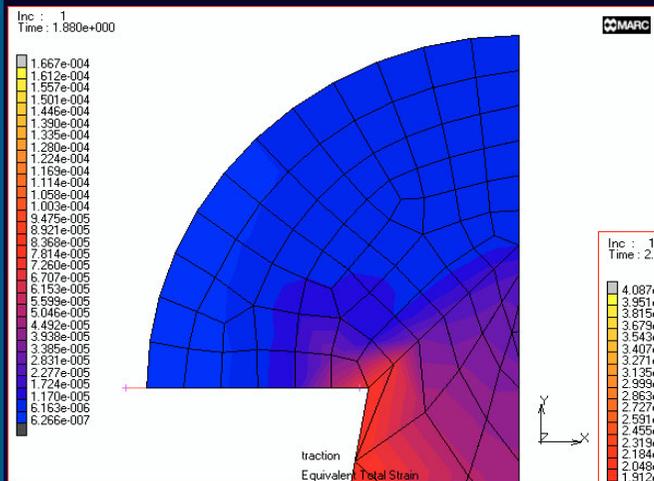
VALIDATE

Virtual testing using FEM without CAM_T

FEM OF PHYSICAL TEST

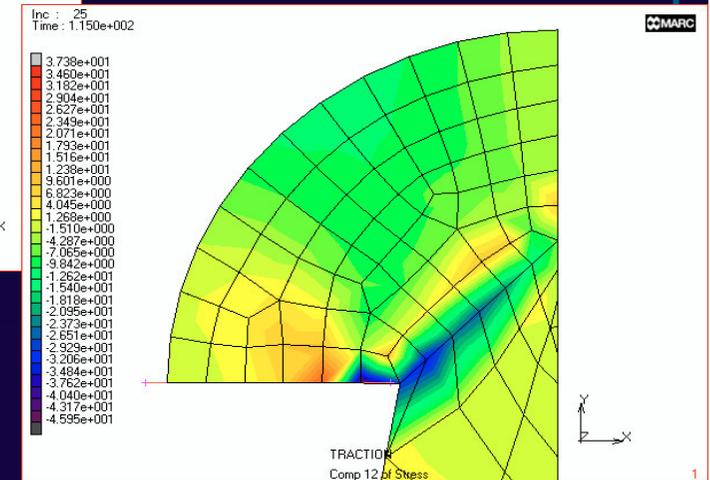
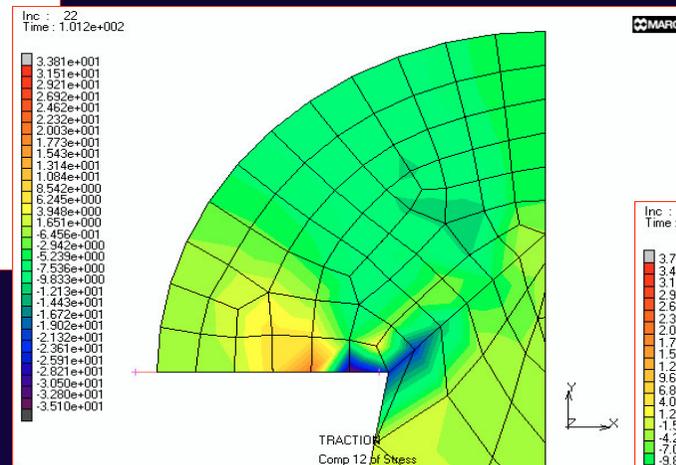
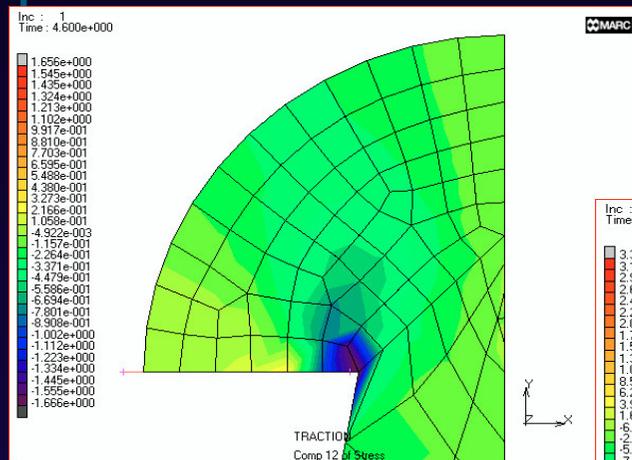


FEM OF PHYSICAL TEST



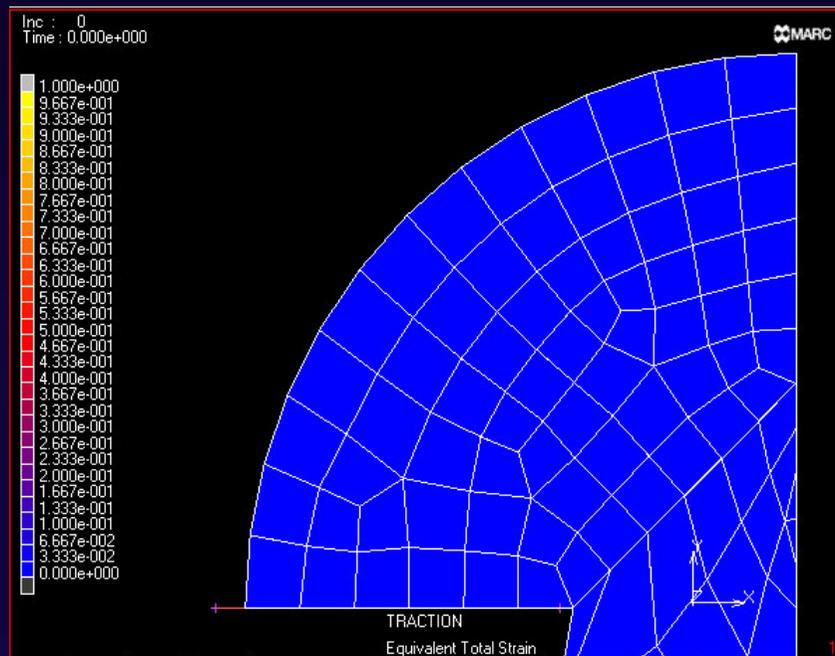
- **NEY Q II – equivalent deformation**

FEM OF PHYSICAL TEST

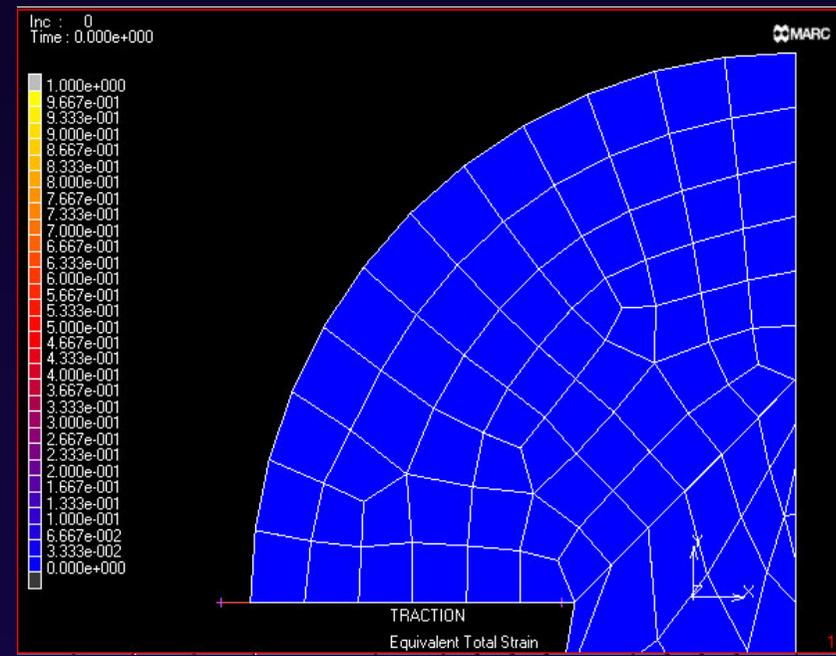


- **REMANIUM C.S. – tension levels**

FEM OF PHYSICAL TEST



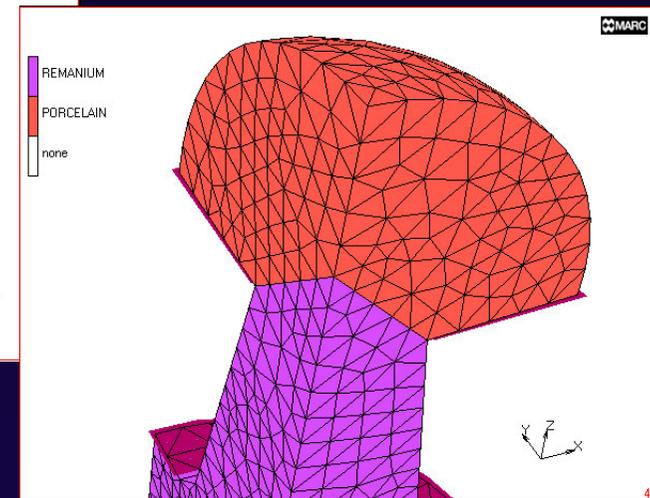
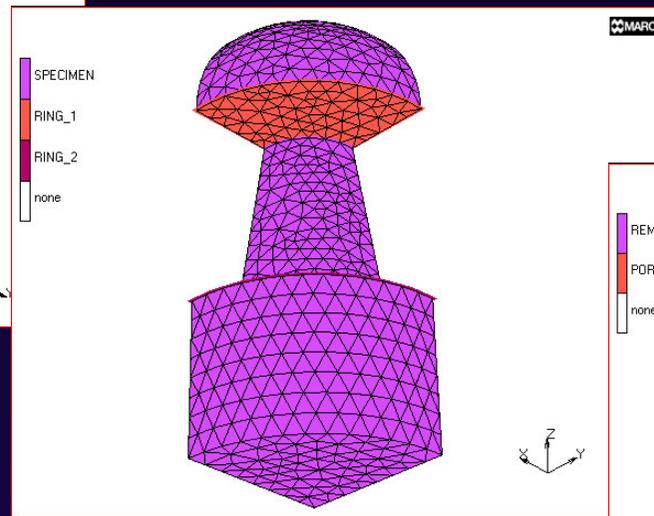
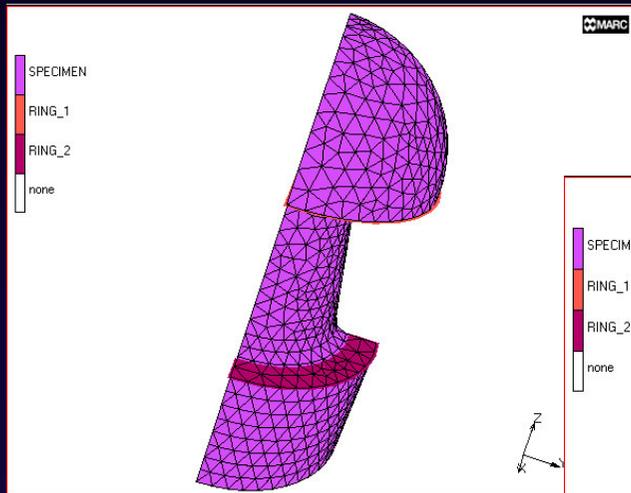
• **NEY Q II**



• **REMANIUM C.S.**

Equivalent deformations

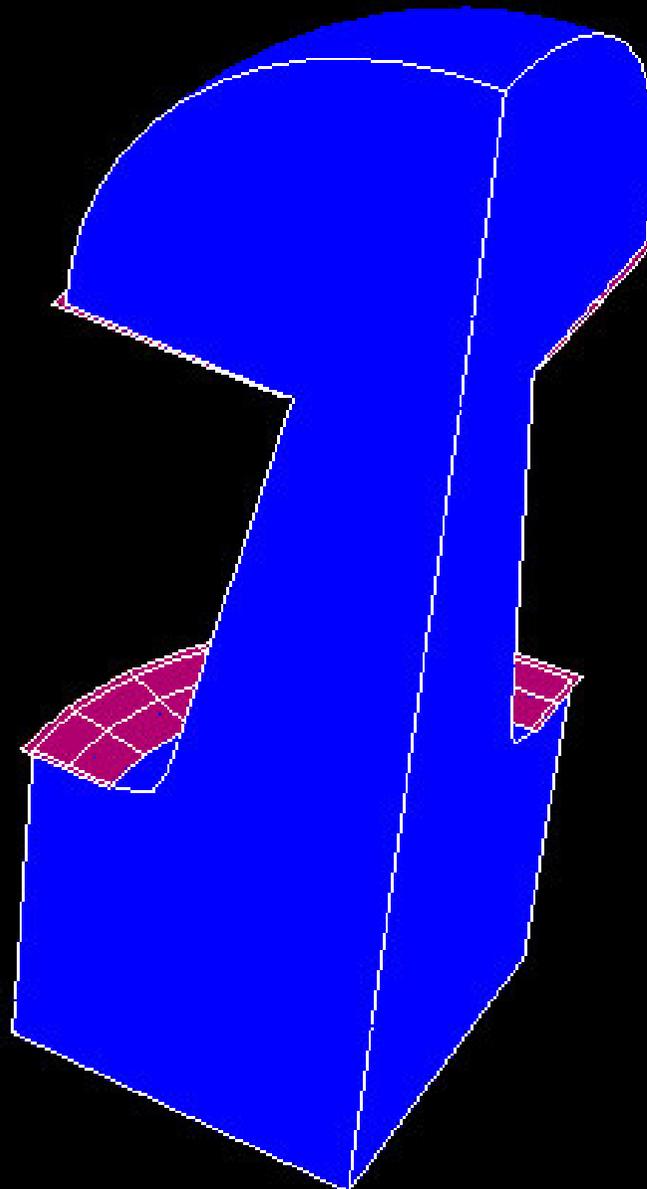
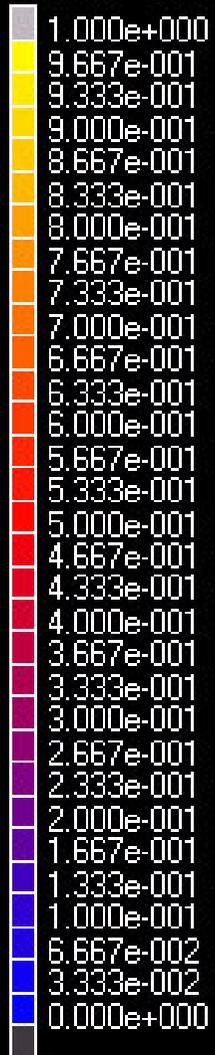
3D FEM OF PHYSICAL TEST



Equivalent deformations - REMANIUM C.S.

Inc : U
Time : 0.000e+000

MARC



Traction - REMANIUM - 3D

Equivalent Total Strain

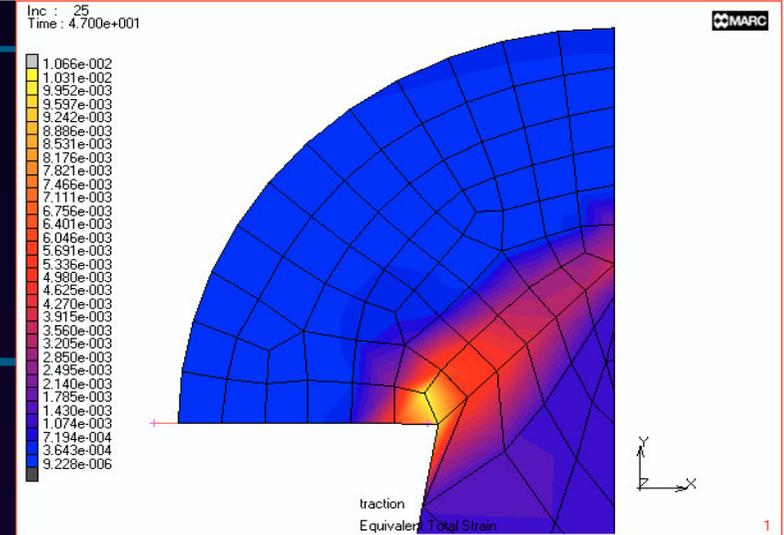
CONCLUSIONS



CAM_T SYSTEM:

- **Corresponds to dental materials tests requirements**
- **Electronic device permits the registration, processing and storing experimental results in real time**
- **Help to find the compatibility between the components of a bi-material (metal-ceramics, metal-polymeric)**

CONCLUSIONS



FEM v.s. CAM_T:

- **Dynamic evolution of critical areas and fracture propagation**
- **Make real the possibility of virtual testing different types of dental materials without creating physical samples**