



THE THEORY OF CRITICAL DISTANCES IN NOTCHED NANO-REINFORCED MATERIALS

Encuentro Internacional de Doctorado en Ingeniería Civil

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Programa de Doctorado en Ingeniería Civil

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THE TCD IN NOTCHED NANO-REINFORCED MATERIALS

- 1 MOTIVATION
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- 4 MATERIAL
- 5 INITIAL PLANNING
- 6 CONCLUSIONS





PERSONAL AND PROFESSIONAL DEVELOPMENT:

- **CONTINUOUS TRAINING**
- **TEAM WORK - OTHER PhD STUDENTS, CO-WORKERS**
- **CONTRIBUTE TO THE EXTENSION OF THE BORDERS OF KNOWLEDGE THROUGH AN ORIGINAL RESEARCH**
- **INTERACT WITH COMPANIES, RESEARCH CENTERS, UNIVERSITIES ETC. THAT RESEARCH SIMILAR SUBJECTS**



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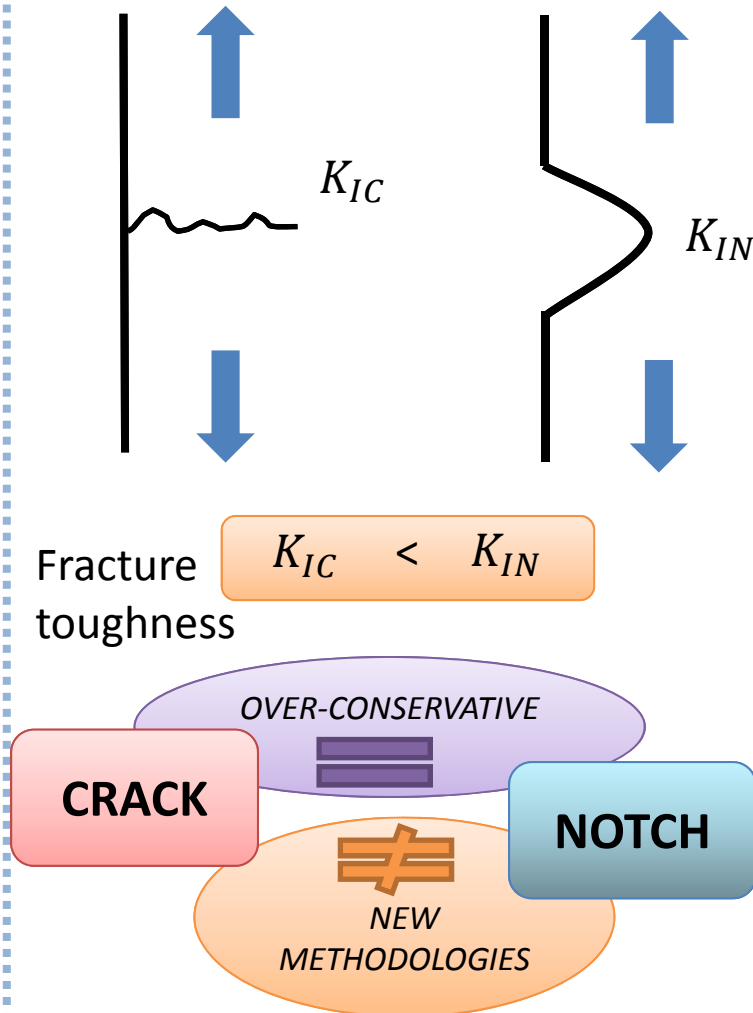
Where?



Director: **Sergio Cicero**

- Civil Engineer PhD - 2007
- Director of Research Area of UC
- Has directed 3 thesis (1 Extraordinary Award)
- Is directing 4 thesis

- A notch is a defect with a FINITE RADIUS on its tip



NOTCH THEORY

- **GLOBAL FAILURE CRITERION:**
ANALOGOUS TO THE FRACTURE ANALYSIS FOR CRACKS ($K_{\rho} = K_{\rho}^C$)
- Lack of analytical solutions for the notch stress intensity factor K_{ρ}
- Lack of standardised procedure for experimental values of K_{ρ}^C

- **LOCAL FAILURE CRITERIA:**
Based on the stress-strain field at the notch tip (easier to apply)

- Point Method (PM)
- Line Method (LM)

TCD

THEORY OF CRITICAL DISTANCES

- The **TCD** is a **group of methodologies**; use a characteristic material length parameter (L) when performing fracture assessments
- **PARAMETERS**
 - CRITICAL DISTANCE **L**
 - INHERENT STRENGTH **σ_0**

MUST BE CALIBRATED

$$L = \frac{1}{\pi} \cdot \left(\frac{K_{IC}}{\sigma_0} \right)^2$$

Material fracture toughness
3 Point Bending Fracture (crack)
Tensile test (σ_u - U.T.S.)

POINT METHOD

$$\sigma \left(\frac{L}{2} \right) = \sigma_0$$

- ✓ *Polymers and metals fracture: $\sigma_0 > \sigma_u$*
- ✓ *Ceramics and **composites** fracture: $\sigma_0 = \sigma_u$*
- ✓ *Analyze all types of defects; simple to apply.*

LINE METHOD

$$\frac{1}{2L} \int_0^{2L} \sigma(r) dr = \sigma_0$$

- For a **CERTAIN** notch **RADIUS** (ρ):

$$K_{IN} = K_{IC} \cdot f(\rho, L)$$

$$f(\rho, L) = \frac{\left(1 + \frac{\rho}{L}\right)^{3/2}}{\left(1 + \frac{2\rho}{L}\right)}$$

**POINT
METHOD**

$$f(\rho, L) = \sqrt{1 + \frac{\rho}{4L}}$$

**LINE
METHOD**

4

MATERIAL

MATERIAL

POLYAMIDE 6 REINFORCED WITH GRAPHENE OXIDE



SPECIMENS



4

MATERIAL

MATERIAL

POLYAMIDE 6 REINFORCED WITH GRAPHENE OXIDE



SPECIMENS

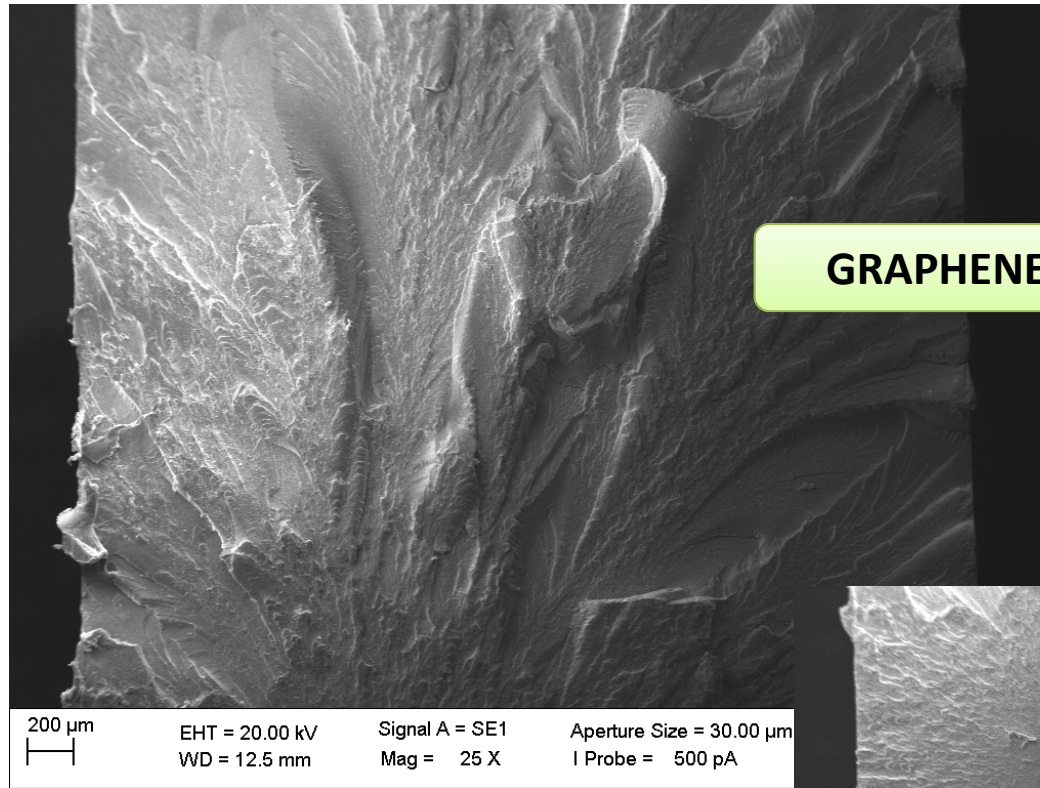
Why so brittle?
G. ox.: inclusion

**FRACTURE
SURFACE**



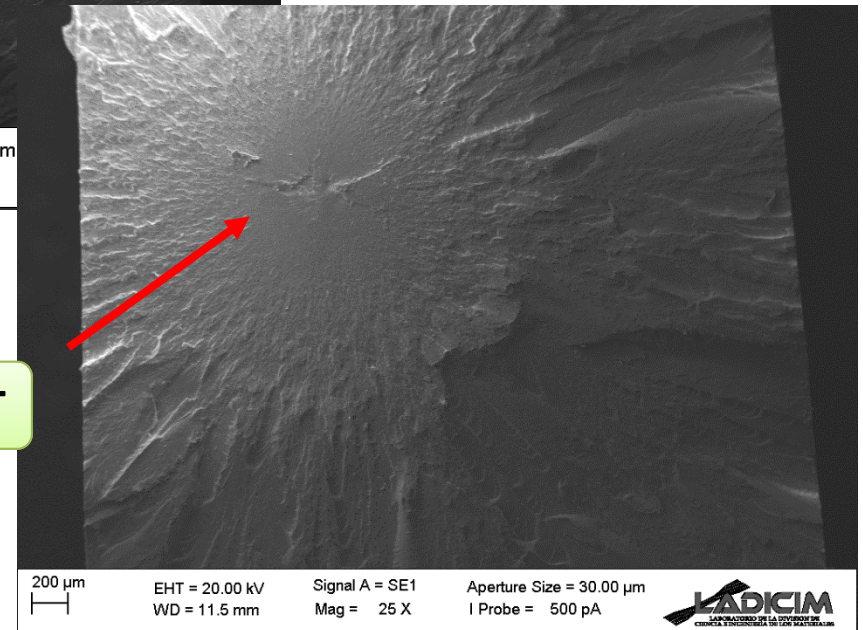
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**SEM (Scanning Electron
Microscope) ANALYSIS**



Cluster of nano-material;
The dispersion needs
to be improved

INITIATION POINT





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Task	2017						2018						2019						
	1-2	3-4	5-6	7-8	9-10	11-12	1-2	3-4	5-6	7-8	9-10	11-12	1-2	3-4	5-6	7-8	9-10	11-12	
State of art - review	█																		
Experimental programme (test etc.)		█					█												
Evaluation model selection						█													
Model validation							█												
Thesis final review																			█
Articles			█																



Make sure there is a propertie's improvement when adding graphene oxide to the polyamide

Improve the dispersion of the graphene oxide:
Search for suppliers to provide us the composite;
Search for companies (CTC) to do the same.

KEEP RESEARCHING





THANK YOU!

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