

# OUTLINE OF THE PRESENTATION

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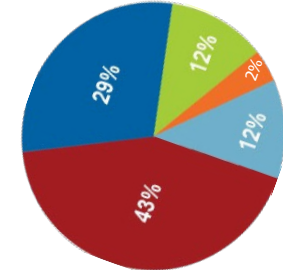
- ❖ **Problem definition**
- ❖ **Existing solutions and associated problems with the existing solutions**
- ❖ **Nature inspirations to provide a solution**
- ❖ **Vulcanization and moulding process**
- ❖ **Obtaining superhydrophobic textures by Laser Surface Texturing (LST)**
- ❖ **Obtaining superhydrophobic textures by punching/embossing**
- ❖ **Characterization, upcoming tests, and some results**



# WE'VE GOT A PROBLEM



Slips, Trips and Falls (STF) are ranked 2<sup>nd</sup> cause of accidents and injuries with 29%



**37.3 million needed medical attention : WHO (2021)**

**Millions need intensive care : WHO**

**Brain trauma, permanent loss of limbs and permanent injuries**

**Loss of Job, absence from the jobs**

**Deaths**

Slips and Falls (SF) on icy surfaces are 39% to 45% of total STF

**Existing solutions:** External devices, Material based, and design based.

**Proposed solution:** Bio-mimicked Multi-Functional Slip Resistant Shoe-sole (wet/dry ice) for indoor and outdoor for ice (wet or dry).

**Capital loss due to absence of workers (Annual \$7 billion, 2012)**

**Permanent loss of skilled and trained workers**

**Burden on Insurance companies**

**Burden on hospitals and expenses on health**

**Plant Held Up (PHU)**

**6,84,000 annual deaths recorded according to WHO (26<sup>th</sup> April 2021)**



# WE'VE ALSO GOT SOME SOLUTIONS

Chains/Crampons/spikes/Cleats



External accessories

Vibram Arctic Grip



Material based solution

Tread Patterns



Design based solution

*Can't use indoor.  
Put on and off every time.  
Tricky for elderly.*

*Expensive (150 to 450 Euros)*

*Lose effectiveness once filled with ice. Wear out and get very slippery.  
Can be problematic for elderly.*

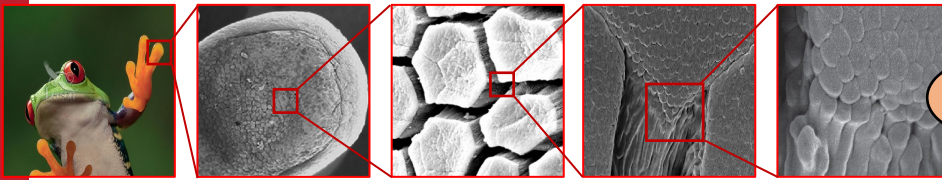


**OOPS**



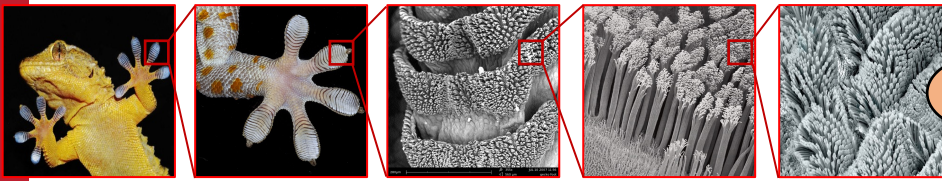
# OUR PROBLEMS, NATURE'S SOLUTIONS

NATURE HAS ALL THE ANSWERS



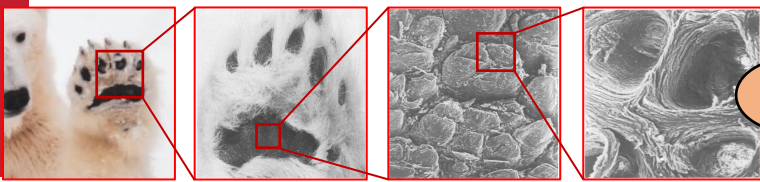
Frog

- Hexagonal soft micro-textures
- Extremely soft nanopillars
- Microchannels



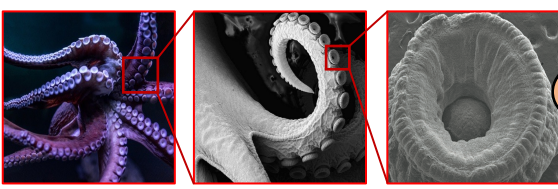
Gecko

- Extremely soft nano-spatulae
- Infinitesimal spaces



Polar Bear

- Conical micro-textures and cavity
- Extra roughness and increase COF



Octopus

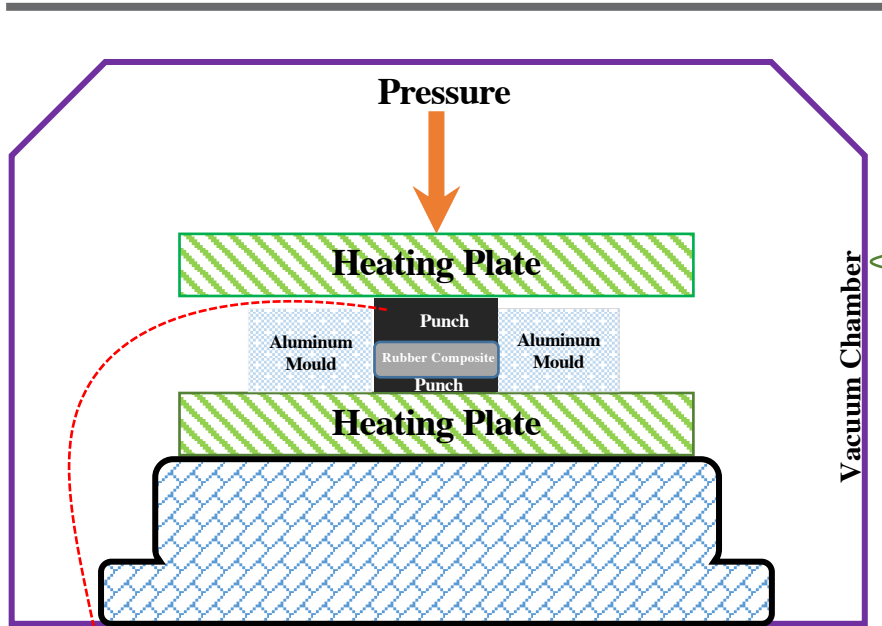
- Soft conical suction cups and sealing
- Pressure difference

Wet adhesion from frog toe pads  
Dry adhesion from gecko feet  
Ice adhesion from polar bear paw

Surface tension or capillarity  
Suction/vacuum  
Surface roughness and properties of the icy surface



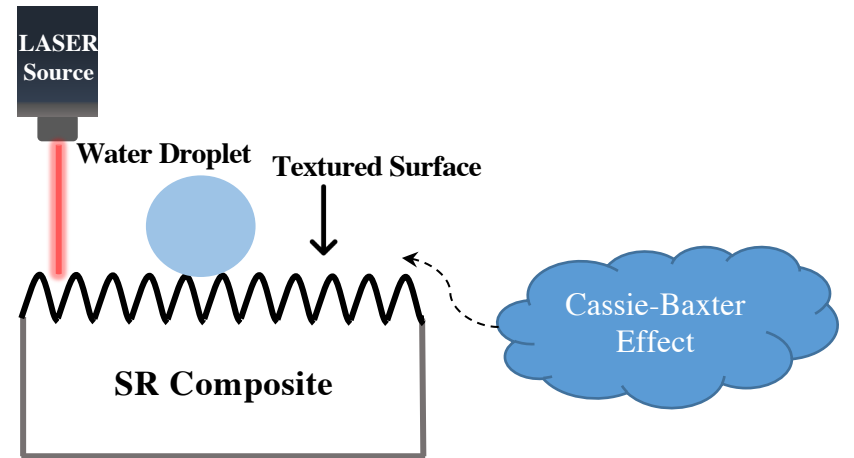
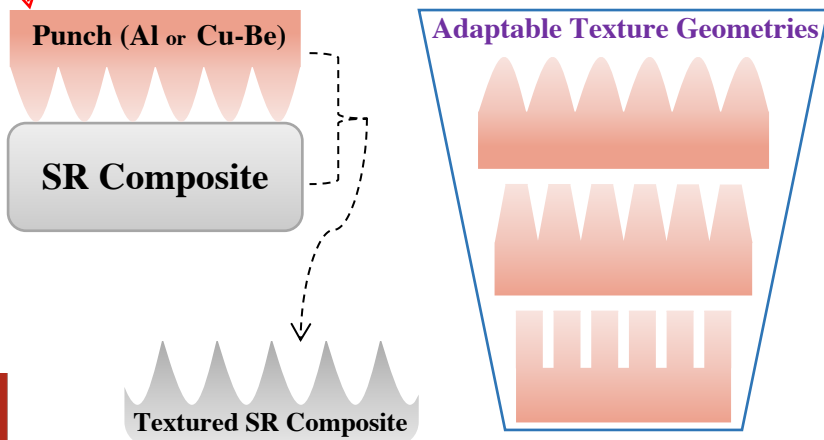
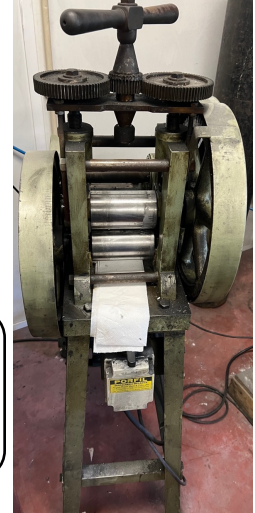
# VULCANIZATION AND MOULDING PROCESS



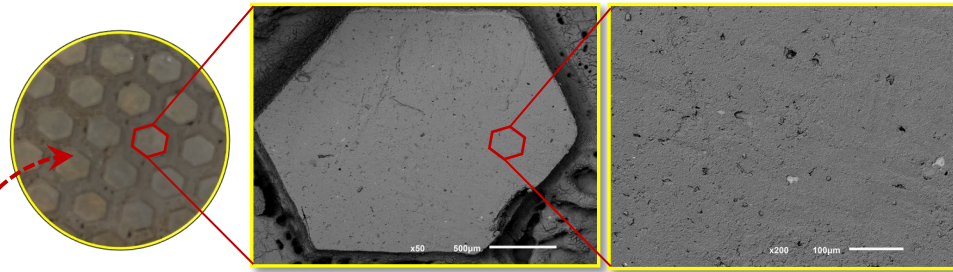
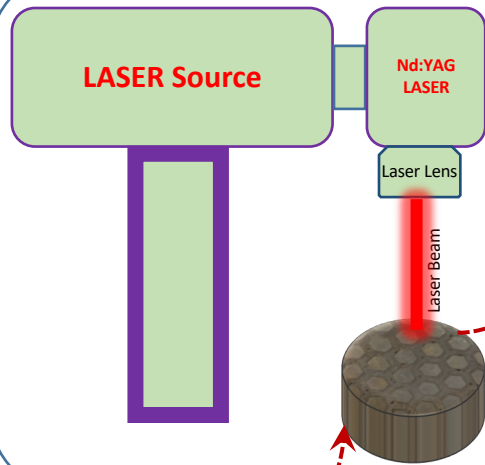
**Salient Features of Moulding**  
Hot compression moulding.  
Aluminum mould (20 mm sample size).  
Aluminum/Cu-Be punch with textures.

**Salient Features of Rubber Composite**  
Silicon Rubber (SR) with Oxide nano-powders.  
Oxide nano-powders are titania and zirconia.

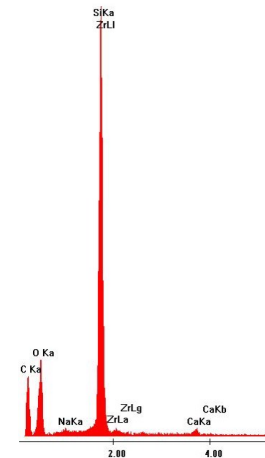
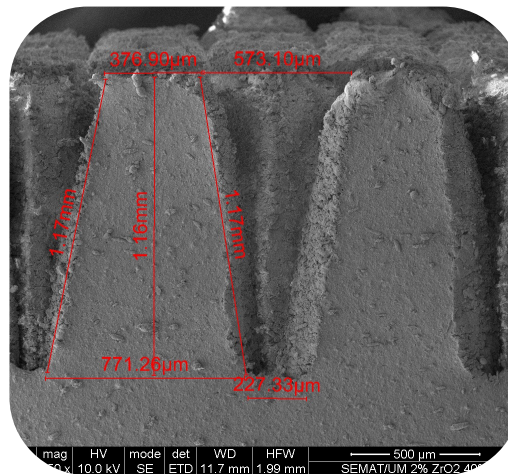
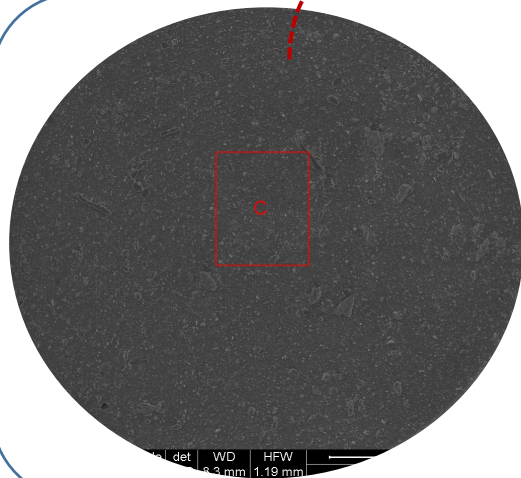
**Innovative Moulding**  
Vulcanize the rubber composite and expose the nano-powders to create the superhydrophobic effect either by Laser Surface Texturing (LST) or embossing using Al/Cu-Be punches



# BIO-MIMICKED LASER SURFACE TEXTURING

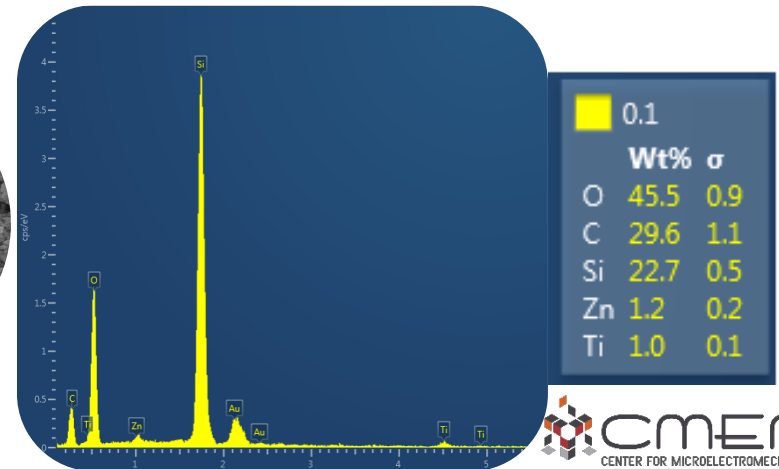
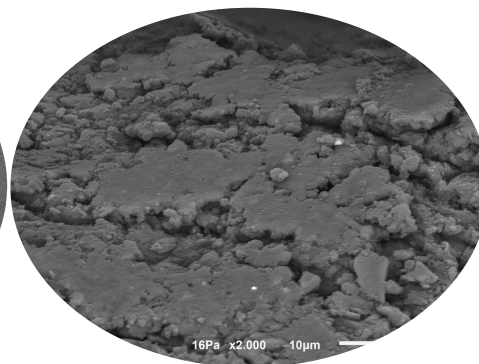
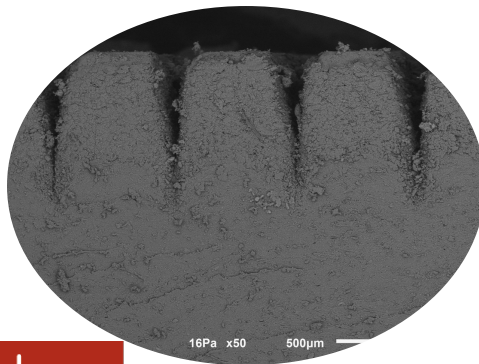
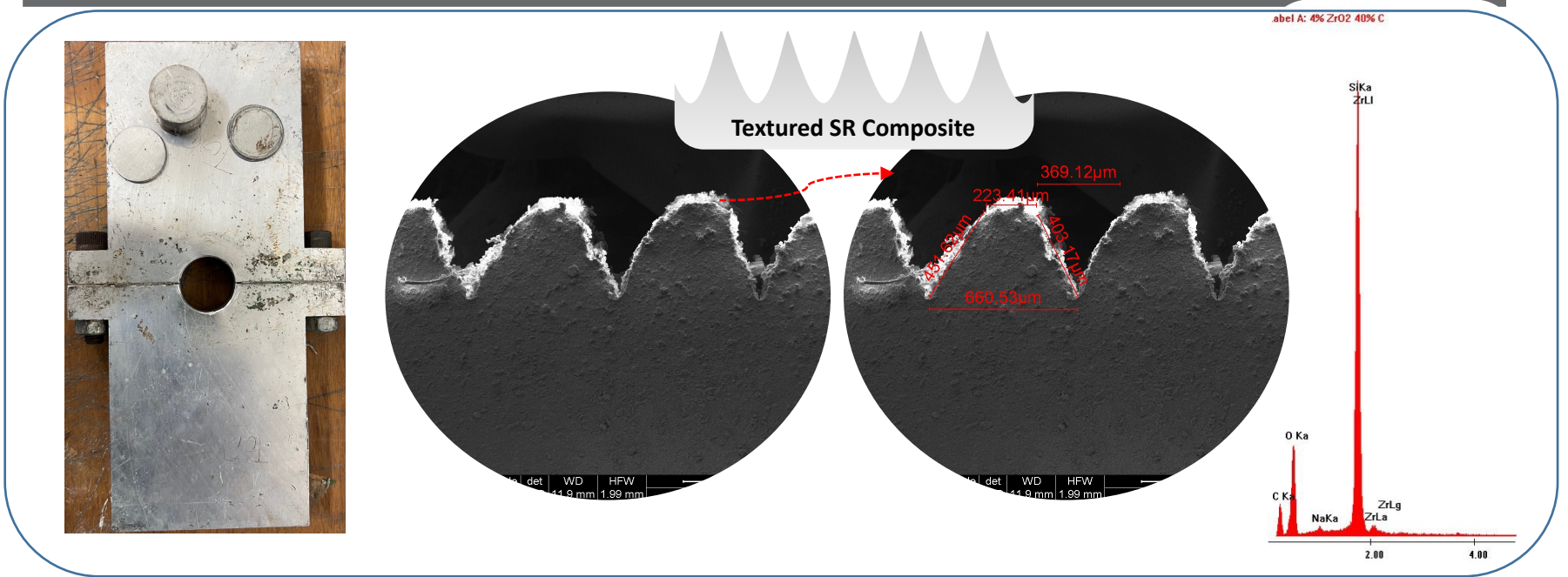


Power, Scanning speed, Jump delay ,  
Laser frequency, Spot diameter,  
Wobble amplitude and wobble  
diameter



# BIO-MIMICKED PUNCH/MOULD TEXTURING

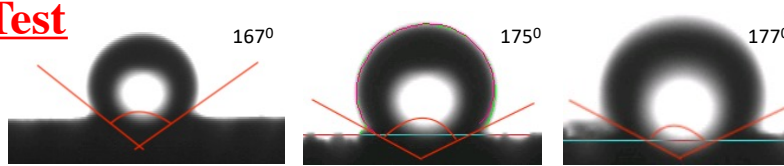
To see the mould textures on Cu-Be, go to Page 11



**Hardness Test: Shore-A Durometer (Sauter GmbH-Germany)**

**Shore A: 36.7, 35.9, 35.9, 36.3, 36.3 = 36.22 (5 iterations)**

**Wettability Test**



Freezing Time  
Calculation

Wettability Test

Wear & Friction Test

Crosslinking Test

Characterizations  
SEM, FTIR, EDS, XRD





## CONTRIBUTIONS

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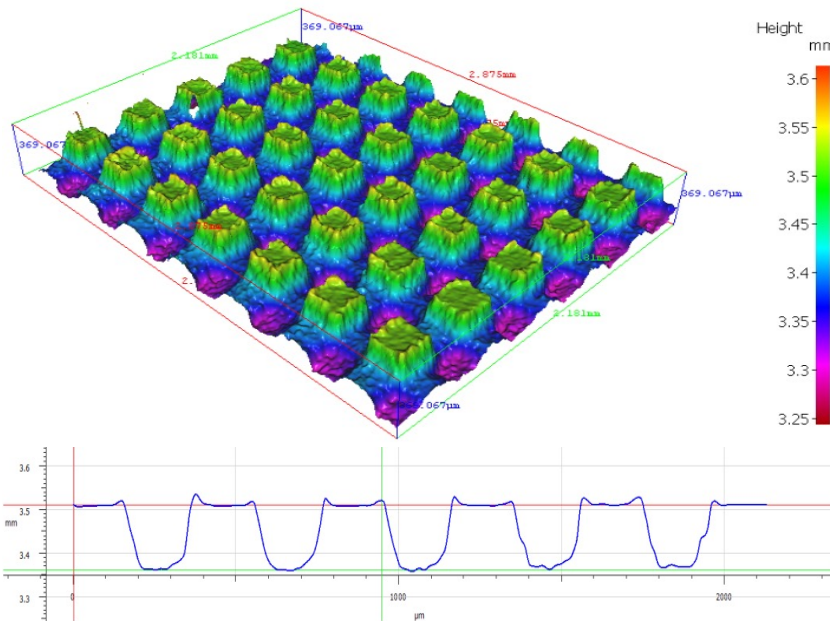
1. Prepared composite of SR with titania and zirconia.
2. Laser Surface Texturing (LST) and Punch moulding for the geometry replication.
3. LST exposed the silica particles to enhance superhydrophobic effects.
4. Wettability tests were done to see the superhydrophobicity. Performed hardness tests.
5. Cross-linking, wear test and ice adhesion would be done in future.

## REFERENCES

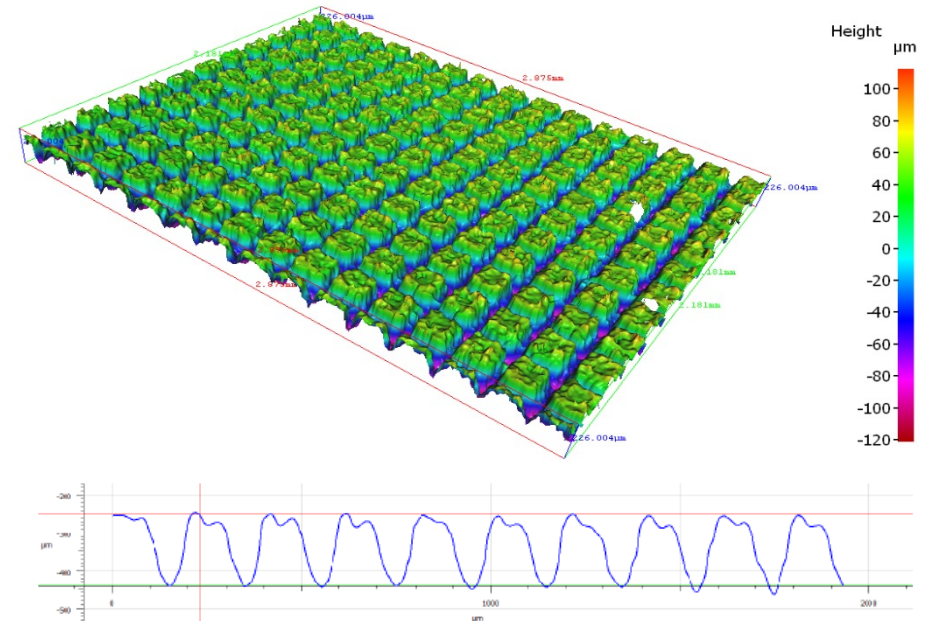
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- Gustavsson, Johanna, Finn Nilson, and Carl Bonander. 2020. "Individual and Contextual Factors Associated with the Use of Anti-Slip Devices According to a Swedish National Survey." *Journal of Transport and Health* 17 (August 2019): 100865. <https://doi.org/10.1016/j.jth.2020.100865>.
- Hippi, M, and S Hartonen. 2012. "Statistical Data of Slipping Injuries Happened in the Winter Time." *SIRWEC*, no. May: 23–25.



# Punch: (Optimized Textures for Copper-Berallium)



ReferencePosition	I: 947.347μm	z: 3.359mm
MeasurePosition	I: 0.000μm	z: 3.511mm
RelativeMeasurement	ΔI: -947.347μm	Δz: 152.049μm
	Angle: 170.882°	Distance: 959.471μm



ReferencePosition	I: 344.165μm	z: -440.820μm
MeasurePosition	I: 227.924μm	z: -250.557μm
RelativeMeasurement	ΔI: -116.240μm	Δz: 190.263μm
	Angle: 121.423°	Distance: 222.961μm

This work was supported by FCT national funds, under the national support to R&D units grant, through the reference projects UIDB/04436/2020 and UIDP/04436/2020, “BioInSole-Multi-Functional Bioinspired Slip Resistant Shoe-Sole” Associação para a Inovação e Desenvolvimento da FCT (Caparica) (PTDC/EME-EME/7860/2020) , and Vipin Richhariya acknowledges FCT for his PhD scholarship through “Projeto e Desenvolvimento de Superfícies Multifuncionais para Controlo do Comportamento à Fricção na Presença de Água (UI/BD/150939/2021)”.





**JUNIOR EUROMAT2022**



# ANTI-SLIPPING WINTER SHOE-SOLES: A NATURE INSPIRED SOLUTION

Presented by;

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University of Minho  
School of Engineering



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CENTER FOR MICROELECTROMECHANICAL SYSTEMS

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*Only if it were easy, wouldn't everyone do it ?*

*- Vipin*

*ITE, MISSA EST*



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