Technical University
of **Leoben**

Science 4 Technology – Poster Exhibition 2026

Department: Polymer Engineering and Science

Chair: Chemistry of Polymeric Materials

Works Council
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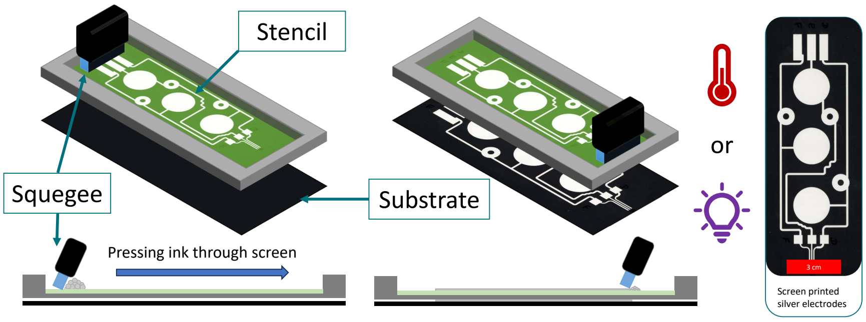
Printed Sensors for Pipes

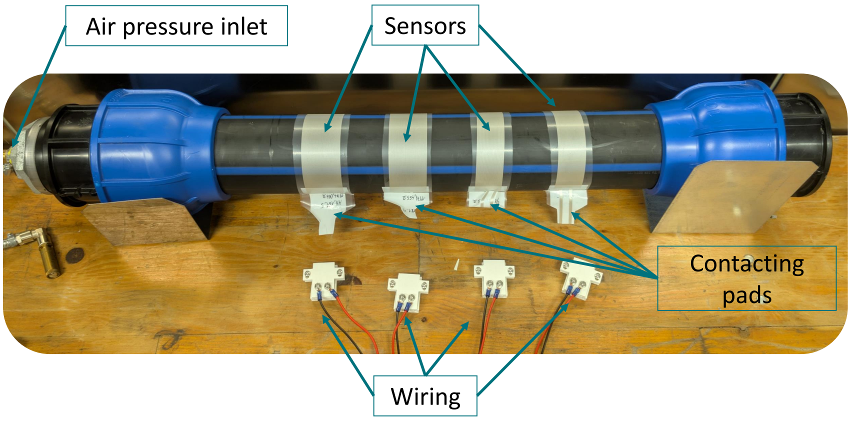
Monitoring Pipe Pressure with Printed Electronics

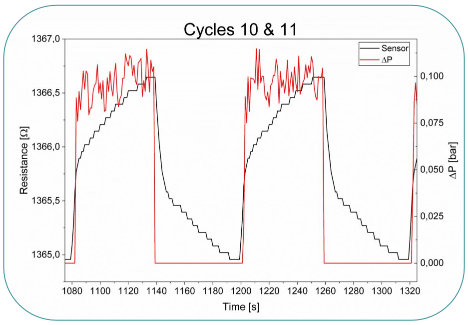
Printed electronics (PE) is a research field in which conventional electronic components are replaced with printed elements using electrically conductive inks. A major advantage of PE is its flexibility and stretchability, which make it suitable for applications in which the material is deformed in use. Depending on sensor design and the electrical resistance of the used ink, even minimal changes can be detected, i.e., the pressure increase in a pipe.

In screen printing, a stencil is created on a screen with a mesh of stainless steel, polyester, or nylon. Ink is pressed through the screen onto a substrate to create the desired pattern, which is then cured via temperature in an oven or with light.

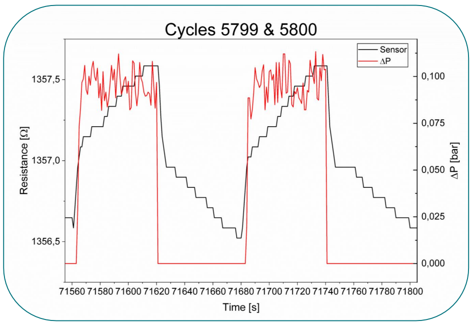


Pipe pressure in an active system reflects a pipe's functionality and status. Unexpected changes in pressure indicate problems such as leaks, blockages, improper pumping, or damage. Conventional monitoring systems can be difficult and costly to install and consume significant power. Using PE enables easy, cheaper, and faster implementation by placing the sensors directly on the pipe.





The printed strain sensors were capable of reliably detecting small pressure changes of 0.1 bar – the strain response could be maintained reproducibly over several thousand cycles under controlled atmosphere (23 °C, 50 % rH).



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- Electro-mechanical characterization of printed electronics
- Long-term stability and characterization of environmental factors on PE
- Cyclic & fatigue testing

mining engineering
mineral economics

Move mountains

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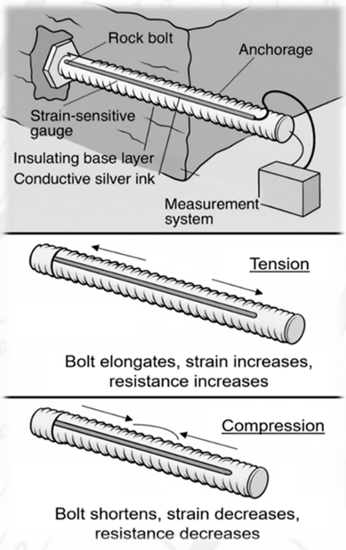
Printed Electronics and Sensors

Smart Rock Bolts for Real-Time Underground Monitoring

Underground mining structures are continuously exposed to mechanical stress, rock deformation, and environmental variations. Conventional monitoring systems are often limited by complex installation, high costs, and low spatial resolution. Printed electronics offer a promising alternative by enabling lightweight, low-cost, and customizable sensors that can be directly integrated onto structural elements. In this work, we investigate the development and deployment of printed strain sensors on rock bolts for real-time underground monitoring.

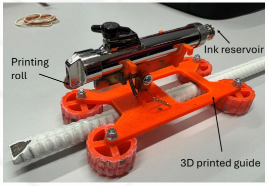
Theory

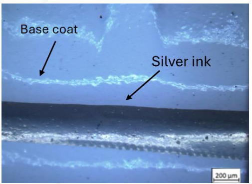


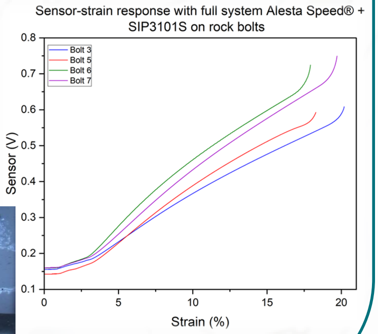
The printed sensor is deposited on the rock bolt using conductive silver ink on an insulating base layer and connected to a measurement system for continuous resistance monitoring. Under tensile loading, the bolt elongates and the electrical resistance of the ink increases. Under compressive loading, the bolt shortens and the resistance decreases. Monitoring these resistance changes enables real-time detection of mechanical deformation and stress changes in underground structures.

Method

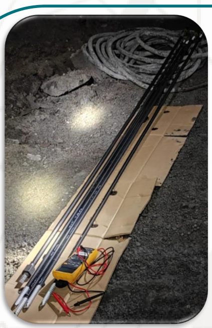
The silver ink is deposited using a laboratory-developed rolling-pen device onto the insulating base layer on the anchor bolt and cured at 120 °C for 20 min. Reproducibility and durability are evaluated during tensile testing until failure. The system must withstand at least 15 % strain to be considered viable.





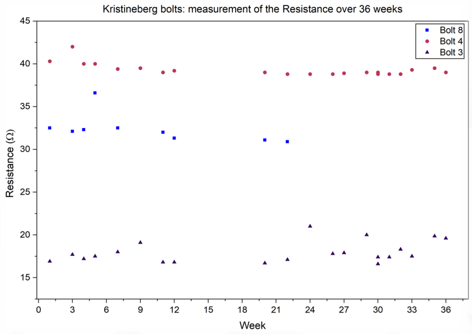


Application



Smart rock bolts equipped with printed sensors were deployed at the Kristineberg mine in Sweden for in-situ monitoring. Over a 36 weeks manual data collection period, the sensors successfully demonstrated their capability to detect deformation within the mine walls.

The integration of printed strain sensors onto rock bolts provides a reliable solution for underground deformation monitoring. This validated proof of concept highlights the technology's strong potential for scalable industrial deployment.



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Screen-printing, Inkjet-printing, Printed Electronics, Strain Sensors

mining engineering mineral economics

DSI UNDERGROUND
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Move mountains

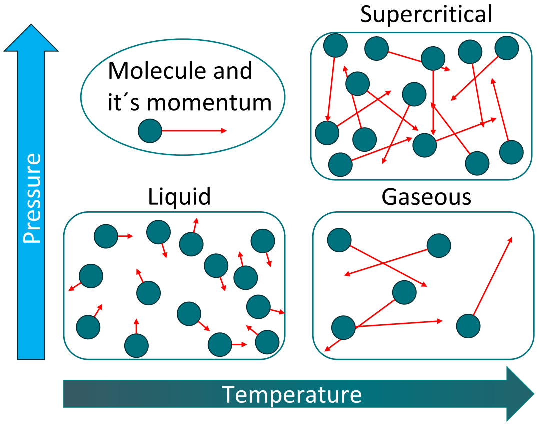
Beyond the Slopes

High-Tech Ski Recycling through Supercritical Separation

Motivation

Modern skis are made from complex composite materials, including polymer matrices, metals, wood and reinforcement fibers like carbon and glass fibers all held together by thermoset adhesives. This multi-layer structure gives the ski its superior mechanical properties but simultaneously makes recycling highly challenging. To overcome the superior adhesion of thermosets such as epoxy or polyurethane resins, separation of skis are supercritical fluids are explored in this work.

Supercritical Fluids

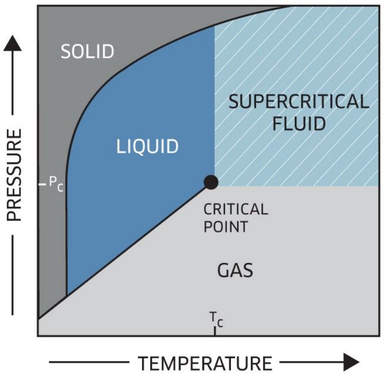


Key Advantages:

- High diffusivity
- Penetration into solid matrices

Theory

Supercritical fluids (SCFs) exist above a substance’s critical temperature and pressure, where gas and liquid phases merge. In this state, they combine gas-like diffusivity with liquid-like density, enabling strong and efficient dissolution. SCFs easily penetrate porous materials, and their solvent power can be precisely tuned by adjusting temperature and pressure—allowing selective extraction of specific substances..

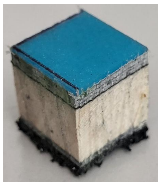


Phase transition diagram with supercritical point
Source: Schonemann, 2021 (Phasex)

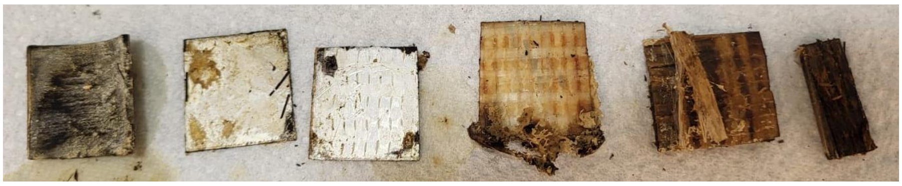
Experimental

Samples of a ski are separated by the application of SCF in an autoclave. All Individual parts such as top and bottom polymer layers, wood core, alloy and glass fiber sheets can be recovered separately and forwarded to recycling.

Results



Separation using SCF



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Visible light Induced Photopolymerization Systems via Immobilized Photoinitiators

Photopolymerization is a light-induced process in which reactive species generated upon irradiation convert monomers into polymers, with propagating species being either radical or ionic. This technique has rapidly developed in recent years and was introduced in several fields such as ink and 3D printing, dental medicine, photolithography ect. However, concerns about potential safety risks have increased due to residual photoinitiators or migration of photodegradation products in recent years (fig. 1a). To solve this issue, some strategies have been proposed to overcome this drawback, like introducing polymerizable groups (like vinyl or acrylate groups) or increasing the molecular weight, such as synthesizing macrophotoinitiators (fig. 1b). Another new method is to covalently couple the photoinitiators to surfaces of different materials, which can induce surface-initiated photopolymerization for surface modification (fig. 1c).

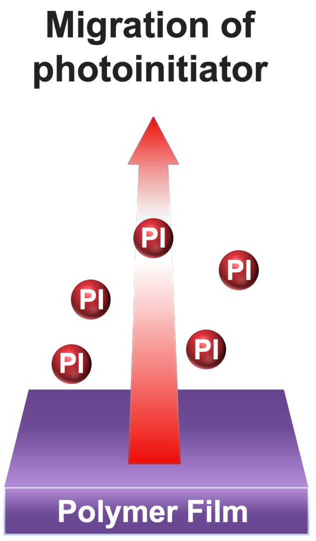

Fig.1a: Migration of photoinitiators

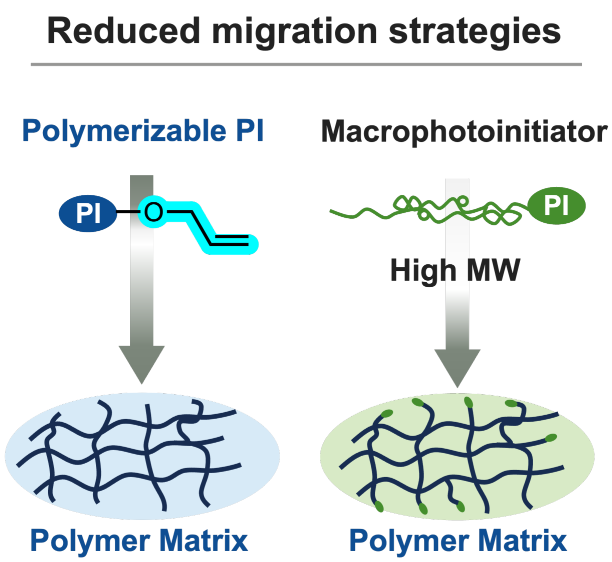

Fig.1b: Reduced migration strategies

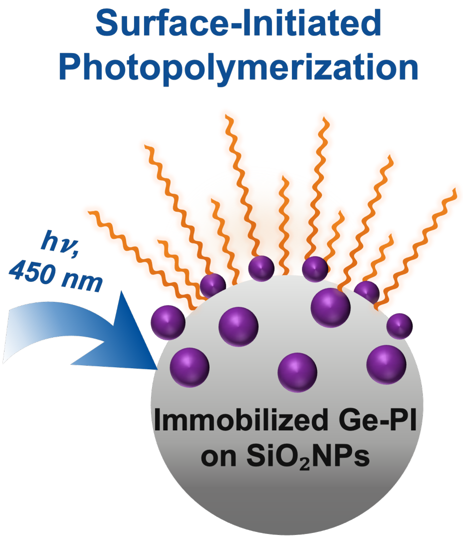

Fig.1c: Surface-Initiated Photopolymerization

A new methodology called Surface-initiated radical promoted cationic photopolymerization (SI-RPCP) was proposed by our group. Firstly, we coupled the Germane-based photoinitiator onto the surface of SiO_2 nanoparticles. Under illumination at $\lambda = 450$ nm, germyl radicals were generated. In the presence of an oxident, the germyl radical can be converted to a cation, which subsequently engages in cationic polymerization of suitable monomers. In this manner, a cationic “grafting-from” process was carried out on silica nanoparticles, with which demonstrated high-density brush formation was achieved. The SI-RPCP approach is ideally suited for the modification of inorganic surfaces with functional polymer brushes since it combines low toxicity with high efficiency under visible-light irradiation, while effectively overcoming the challenge of O_2 intolerance due to the cationic reaction pathway.

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Research focus:

Surface Modification;

Immobilized Photoinitiator Synthesis

ESPERANTO
Enhancing the Sustainability of PhotopolymERs ANd phoToinduced prOcesses

MARIE CURIE ACTIONS
DOCTORAL NETWORK

O_2- and N_2-Plasma treatment of Carbon Electrodes

Enhancing the electrochemical performance of vanadium redox flow batteries

Introduction

Enhancing the electrochemical activity of electrodes is crucial for the large-scale production of high-performance vanadium redox flow batteries (VRFBs). A key challenge with RFBs is optimizing the carbon felt (CF) electrodes, especially their long-term performance. This study investigates surface modification via O_2- and N_2-plasma treatments to enhance the catalytic activity and electrochemical stability of CF electrodes.

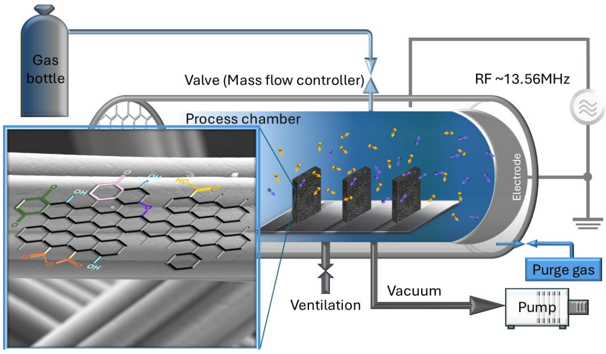

Fig 1. Scheme of plasma treatment

Methodology

O_2-plasma: CF was treated at 50-100 W for 2.5 minutes.
N_2-plasma : CF was treated at 100-200 W for 5 minutes.

Performance Enhancement

Plasma treatment significantly boosts VRFB performance (Fig. 2):

Pristine CF: High activation polarization; peak power density of 280 mW·cm^{-2}.

Plasma-treated CF: Peak power increased up to 460 mW·cm^{-2} (N_2-100W).

Mechanism: Surface functionalization and defect generation enhance charge-transfer kinetics and electrolyte accessibility.

Power Density Retention (20 Cycles)

Pristine and O_2-Plasma: Performance dropped 8–15 % due to the instability and induced surface functional groups.

N_2-plasma: Minimal decay (≈1 %), demonstrating superior electrochemical stability due to stable nitrogen-doped active sites.

Conclusion

While plasma treatment significantly boosts initial VRFB performance, only the N_2-100 W treatment maintains exceptional durability with approximately 1% power loss. These results demonstrate that plasma conditions must be precisely optimized to achieve the ideal balance of high catalytic activity and long-term electrochemical stability.

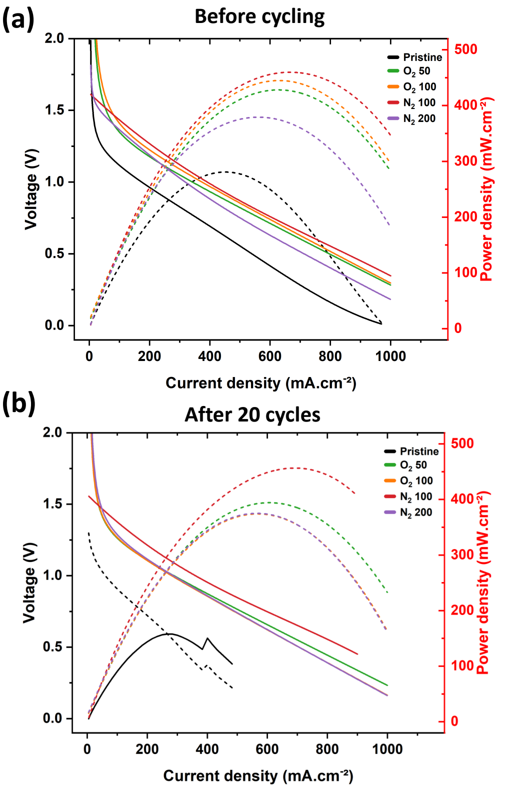

Fig 2. Polarization curves of the pristine, O_2- and N_2-plasma treated electrodes (a) before cycling and (b) after 20 charge-discharge cycles.

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