Warsaw University of Technology
Faculty of Materials Science and Engineering

Neutrons as a study probe in the research of advanced materials

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Faculty of Materials Science and Engineering

4 divisions

Division of Surface Engineering
Division of Ceramic Materials and Polymers
Division of Structural and Functional Materials
Division of Materials Design

A scientific category

High level of research confirmed by the very high category in the parametric evaluation of research units.

20 research groups

Interdisciplinary research concentrates on the links between macro-, micro- and nanostructure, and properties of materials, e. g. composites used in various branches of the industry. Strong collaboration with the industry.

140+ people

140+ members of staff, including 51 academic teachers, 75 scientific and technical employees and 22 administration employees.

70+ projects

Several dozens of R&D projects funded by both European Funds and National Funding Institutions.

www.wim.pw.edu.pl

Main research domains

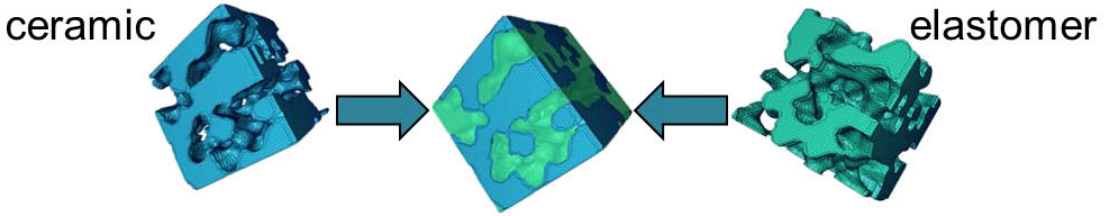
Biomaterials and bioengineering	3D Printing	Polymer matrix composites and polymers
Computational modelling	Nanomaterials and ultrafine materials	Materials for energy sector
Advanced functional and structural materials	Ceramics and ceramic matrix composites	Surface engineering and heat treatment

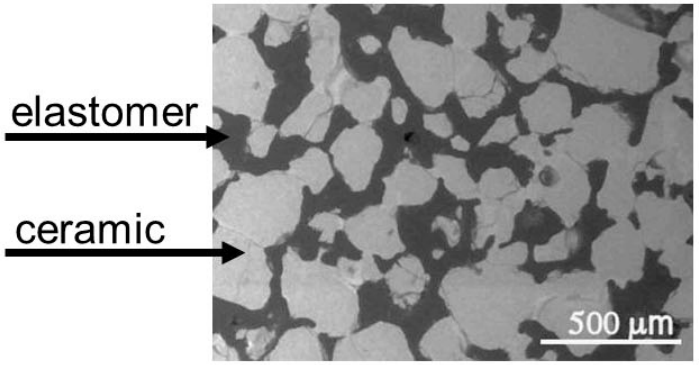
Experience in neutron study of PU elastomers

Measurements of residual stresses in PU cured in ceramic pores

Experiment Title : Residual stresses in ceramic-elastomer composites (proposal no. 9-12-107)

Experiment place: D7 (**Diffuse Scattering Instrument)** - ILL Grenoble (May 2007) - WANS Study with Polarized Neutrons

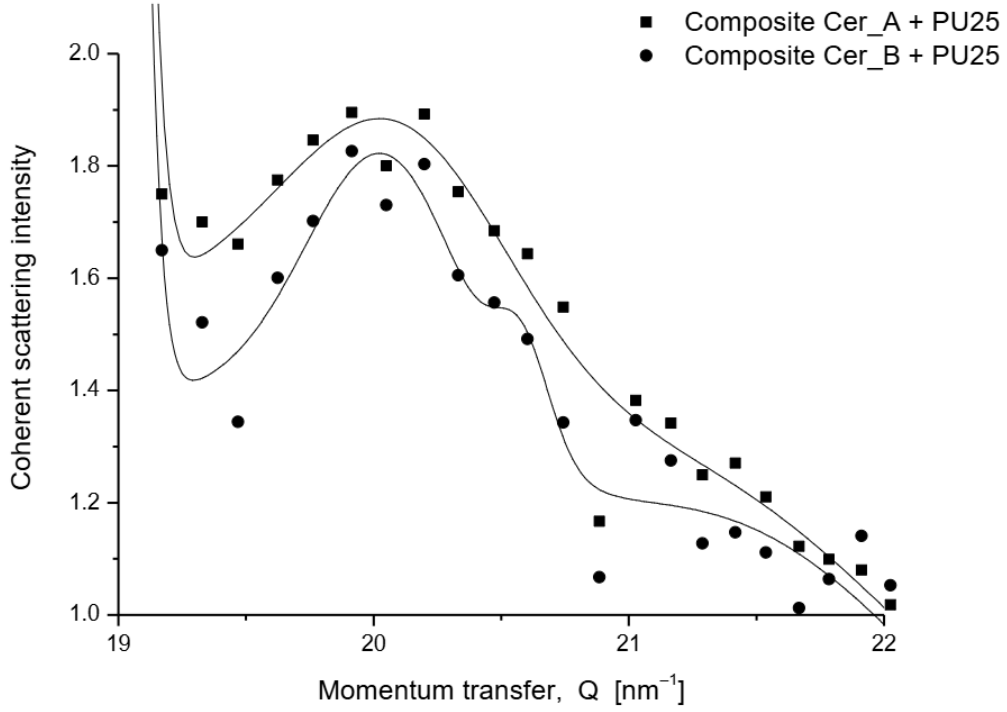




Curing of elastomer is carried out inside ceramic pores at temperature elevated up to 120°C → Residual stresses formation

W. Zając, A. Boczkowska , K. Babski, K.J. Kurzydłowski, *Measurements of Residual Strains in Ceramic-Elastomer Composites with Diffuse Scattering of Polarized Neutrons*, Acta Materialia 56 (2008) 5964–5971

Results - coherent neutron scattering spectra of a composite A & B and elastomer PU25



- 'Soft-segment' peak in both composites of type A and type B ceramics with the PU25 elastomer.
- Peak width corresponds to the correlation length.
- Broader peak means smaller correlation length inside smaller pores.

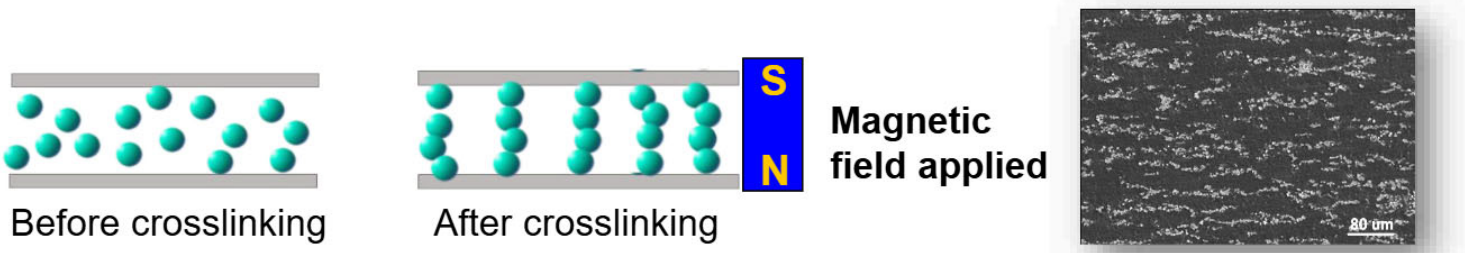
Experience in neutron study of MRE elastomers

Measurements of the influence of various factors (composition, magnetic field strength, sample history) on domain anisotropy in magnetorheological elastomers.

Experiment Title : Reversible and irreversible effects of magnetic field upon hard-segment domains in magnetorheological elastomers (proposal no. 1-04-78)

Experiment place: D11 - ILL Grenoble (May 2013) - small angle neutron scattering (SANS)

Composites of ferromagnetic particles in non-magnetic, viscoelastic polymers.

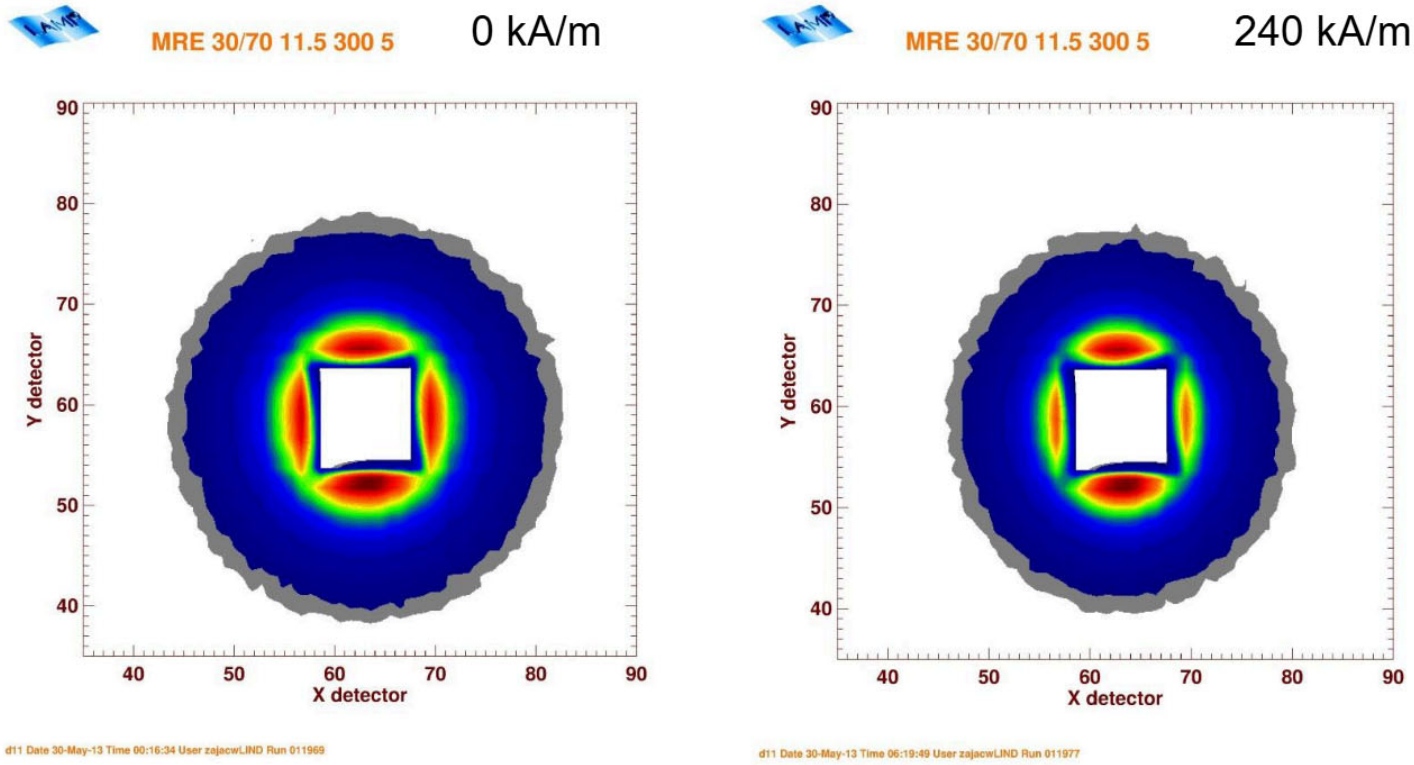


They change their properties, shape and size continuously, rapidly and reversibly under the influence of an applied magnetic field.

W. Zając, The Henryk Niewodniczanski Institute of Nuclear Physics, Polish Academy of Sciences

Results – field dependence of domain anisotropy

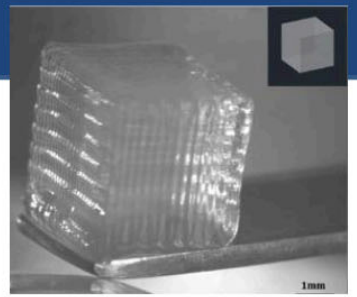
Field-induced (240 kA/m) anisotropic response of elastomer domain structure



Deformation of SANS image in MF – enhanced contrast

ESS in biomaterials research

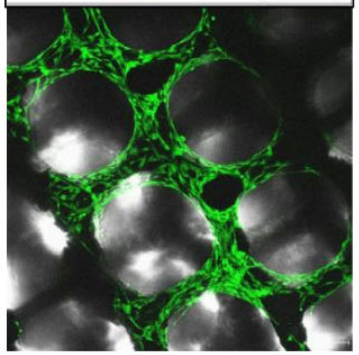
- Studies of the structure of hydrogel materials used as carriers for cells or other biologically active substances
- Studies of the degradation of polymer-based biomaterials
- Studies of tissue–implant interactions/interfaces
- Investigation of fluid flow in bioreactors for 3D cell culture
- Studies of drug diffusion in hydrogel-based carriers
- Studies of residual stresses in materials resulting from 3D printing processes



Gelatine/ Alginate hydrogel

PCL scaffold

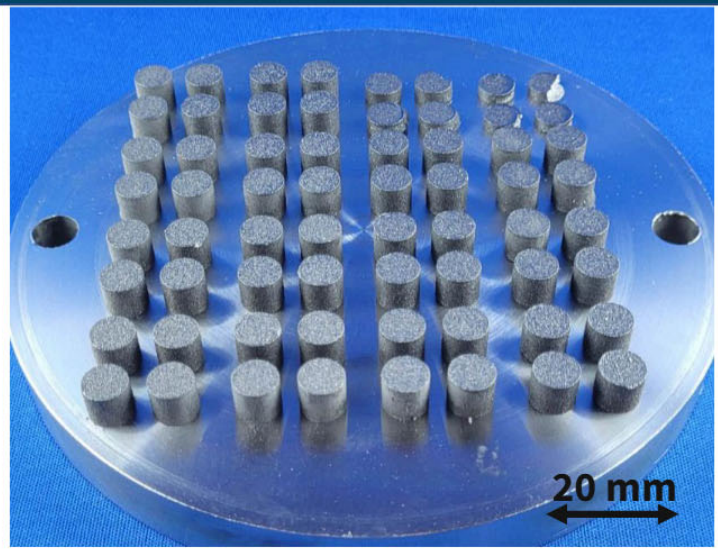
Mg implant in bone tissue



3D printed porous Titanium

ESS in Nd-Fe-B alloys research

- The objective is to determine how the additive manufacturing processes influence the microstructure, and the magnetic performance of the alloys.
- 3D printed hard magnetic Nd-Fe-B alloys processed by **L**aser **P**owder **B**ed **F**usion method.
- The investigation of microstructure, phase constitution and magnetic properties versus composition and LPBF processing variables.



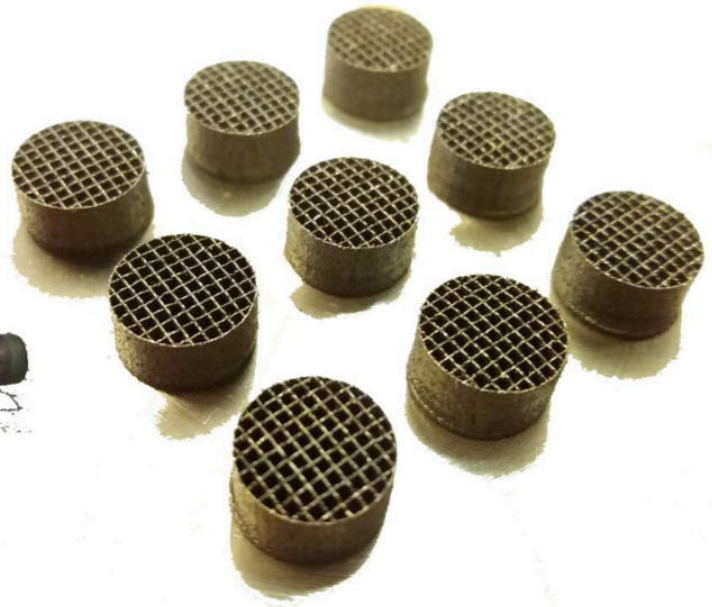
Scope of the study:

- Temperature controlled phase constitution and magnetic properties evolution in 3D printed Nd-Fe-B alloys
- Two alloy compositions Nd-lean and Nd-rich, respectively: Fe-75.7 Nd-23.3, B-1; Fe-66.4, Nd-32.6, B-1; [wt.%]
- Investigation of phase constitution versus temperature in the range of 20^{o}C to 400^{o}C,
- Magnetic hysteresis measurements in a field of min. 2T, at the temperatures of the diffraction tests.

ESS in magnetic functional alloys research

- Texture examination in 3D printouts and single crystals
- Phase constitution of multi phase/variant single crystals, e.g. Ni_2XY Heusler alloys

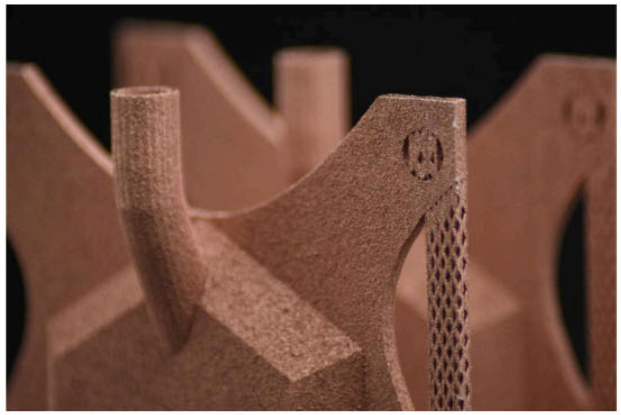
We are interested in experiments in the external magnetic field – up to 5 Tesla,
various temperatures – 80-500K, and pressure – up to 1 GPa,
as well as dilatometry under compression/tension.



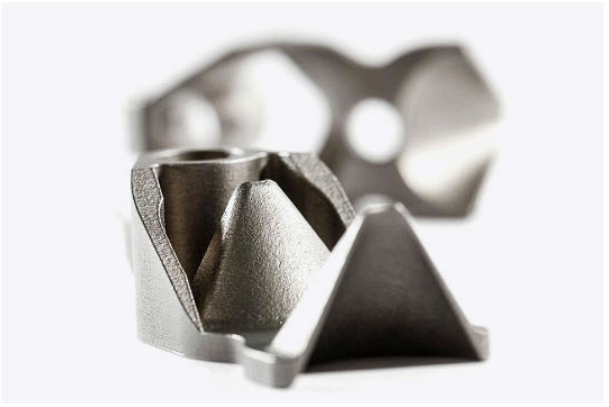
ESS in the Analysis of 3D Printed Metal Components

- Residual stress analysis – fast and precise scanning of stresses generated during the printing process.
- Microstructure and texture studies – analysis of the crystalline structure of the sample, including in situ.
- In situ/in operando experiments – real-time studies.
- Phase and structural transformation identification – tracking phase transformations.

Turbine blade - nickel alloy



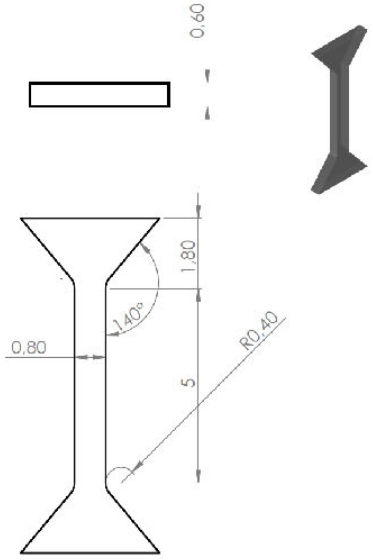
Radiator/Heat Sink Part – Copper Alloy



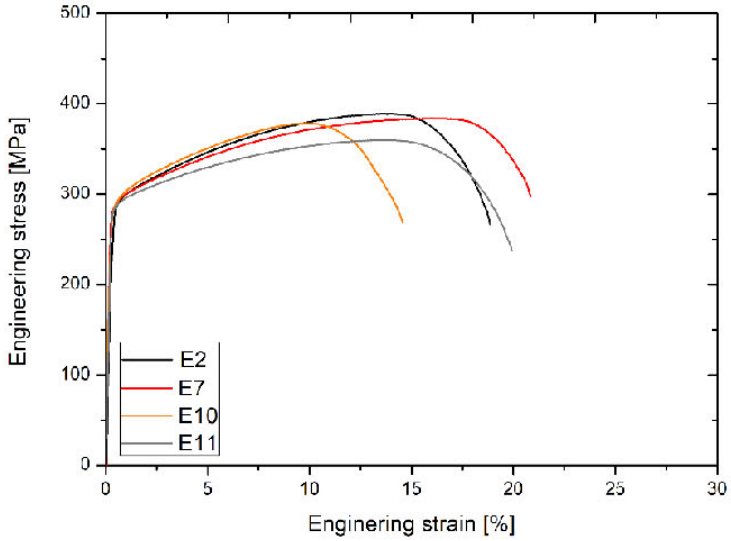
Engine component – 316L stainless steel

ESS in studies of the effect of WEDM processing parameters on internal stresses of miniature specimens

The analysis of the effect of wire electrical discharge machining (WEDM) parameters on the mechanical properties determined using miniature type 5 specimens, indicated a negligible impact of WEDM parameters on ultimate tensile strength (R_m) as well as the observed range of uniform elongation (A_g) and total elongation (A).



Miniature specimen "swallow" type designed at WUT by R. Molak



Engineering stress-strain curves for miniature specimens made of CuCrZr machined with various WEDM parameters (E2, E7, E10 and E11)

Scope of the studies:

Does WEDM processing result in stresses inside the material.
How deep can they reach.
How can this effect on the mechanical properties determined using miniature specimens.

ESS instruments for studies od advanced materials

- BEER Engineering Diffractometer
- MAGiC Magnetism Single-Crystal Diffractometer
- HEIMDAL Hybrid Diffractometer
- ……

Thank you for attention