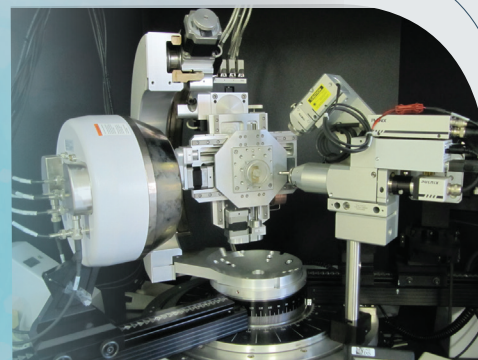


D8 Discover X-ray strain scanner



D8 Discover is a high-resolution X-ray diffractometer (XRD). The interaction of the probing X-ray radiation with the atomic planes in crystalline materials is captured in characteristic patterns with the peak intensities related to the chemical composition and peak positions to the interatomic spacing. This, in conjunction with shallow penetration of X-rays, enables studying of near-surface characteristics to depths of 20 μm into metals (deeper for less-dense, low atomic number materials). Notwithstanding surface limited, depth-resolved investigations are possible with a layer removal method such as electrolytic polishing, or alternatively more invasive techniques such as cutting or slitting.

Micro-diffraction, small beam sizes, combined with XRD on this instrument is useful for investigations of:

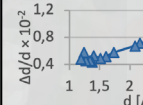
- Spatially-resolved chemical phase analysis;
- Stress/strain in thin films, coatings and surfaces of engineering components;
- Following effectiveness of surface modification processes such as polishing, grit-blasting, laser-shock peening, irradiation, ion implantation, etc.;
- Texture analysis.

Applications are widely used to investigate phenomena in scientific interests in physics, chemistry, materials science and engineering.

This instrument is integral to the suite of X-ray and neutron instruments within Necsa's Beam Line Centre and directly complements the capabilities of the MPISI neutron strain scanner.

XRD Technique for Stress Investigations

Bragg peak positions are related to the interatomic spacings as built-in strain gauges that are measured with XRD. Localised changes are influenced by the strain field. Residual stresses are calculated by incorporating the elastic moduli.

Technical specifications	
X-ray source - selectable	Cu, Co, Cr
Monochromator	Graphite crystal
Beam sizes [mm]	Various Collimator Pin holes: 0.05, 0.1, 0.3, 0.5, 0.8
Sample stage	¼ Eulerian Cradle with integrated ϕ , χ , ψ , θ , γ , δ movements. $X_{\text{travel}} = 150$, $Y_{\text{travel}} = 150$, $Z_{\text{travel}} = 12$ mm
Max sample dimensions [mm ³]	130 × 130 × 20
Max sample weight [kg]	2
Detection system	Vantec 500 area detector covering 18° @ 20 cm sample detector distance
Sample alignment	Combined laser and video camera to accuracy of 20 μm
Omega range	10° ≤ 2 θ ≤ 130°
Detector range	Front side: 10° ≤ 2 θ ≤ 105° Back side: 105° ≤ 2 θ ≤ 135°
Analysis software	• Leptos (stress investigation) • Multex (Texture analysis).
Resolution	

Instrument characteristics directed at stress investigations:

- Small beam sizes - Facilitates spatially resolved micro-diffraction investigations;
- ¼ Eulerian cradle - Facilitates true side-inclination stress measurement geometry;
- Large area detector - Captures significant sections of the Debye-Scherrer scattered intensities - improved measurement statistics - identification of large grains and texture variations.
- A laser/video system - Quick sample alignment and setup to within 20 μm accuracy

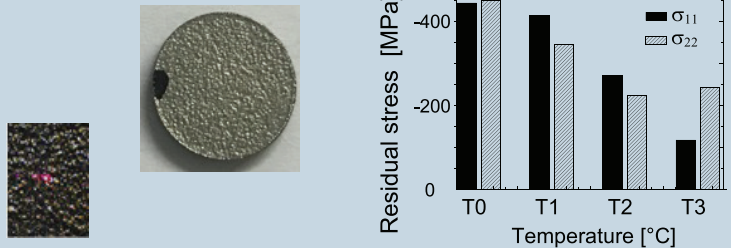
Access to the Discover instrument is through scientific merit of submitted project proposals within the open access User Program where results are published in the open literature. Commercial (proprietary) access is also available.

Case Studies

The non-destructive material microstructure probing contributes value addition to a wide range of scientific disciplines:

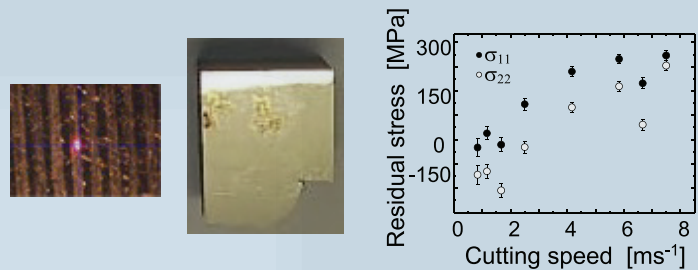
Optimisation of New Technologies

Additive manufacturing technology uses high-energy laser beams to produce metal parts directly from 3D electronic models. Despite many advantages, optimisation of the build parameters are essential to mitigate detrimental effects. Results depicted here show the beneficial effect of heat treatment on the residual stresses in a 3D printed component.



Machining processes

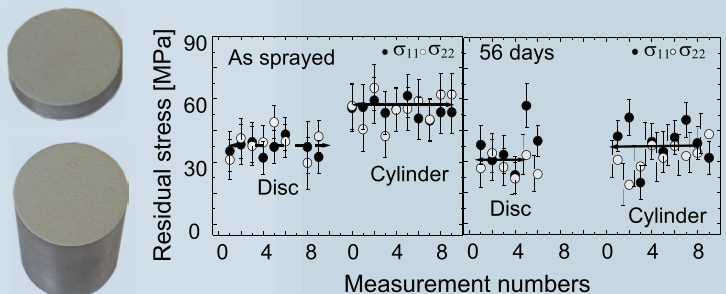
Machining operations shape, cut, or remove material to form workpieces. Residual stresses are inherent to these processes and can impact workpiece performance, structural integrity, and fatigue life. The results show the effect of cut speeds on residual stresses in a steel workpiece.



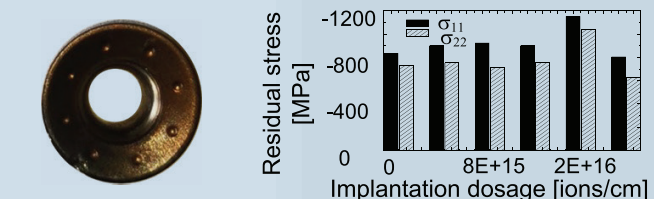
Surface Enhancement/modifications

Surfaces in components are susceptible to localised damage in practical applications. This can be mitigated through surface enhancements such as ion implantation, chemical implantation, coatings, etc. A number of case studies are presented:

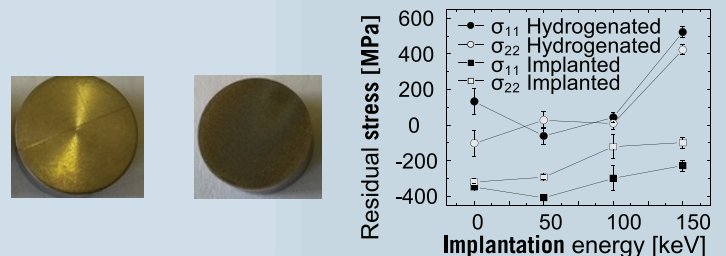
a) Coatings: Bioactive coatings are used in biomedical applications to replace or repair partial functionality of the human body. These are generally produced using plasma spray techniques. Residual stresses, thermal decomposition and reduction in crystallinity can affect coating integrity. Depicted are the typical time evolution of the residual stresses in coatings exposure to simulated body fluids.



b) Ion implantations - Tool bits: Face milling inserts machining operations endure intensive impact on the cutting surfaces. Potential benefit of ion implantation to improve the performance of metallic coatings milling inserts are shown in terms of the residual stresses as function of implantation dosage.



c) Ion implantations - Energy storage materials: With hydrogen energy being a promising pathway toward a low-carbon and sustainable energy future, challenges exist regarding its storage. Results depict the residual stress response to implantation and hydrogenation in metal hydrides.



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