Hard coatings based on CrN are routinely used to protect bulk materials from abrasion and corrosion [1, 2]. The successful application of those coatings demands an optimisation of thermal fatigue resistance in order to avoid cracking or rupture of the coating [3-5]. The optimization resides primarily in the engineering of coating nano-structure, residual stress state, interface properties and substrate pre-treatment [6,7]. Residual stresses in coatings and in the surface region of substrates influence significantly mechanical properties and lifetime of coated working tools. It is believed that high-compressive stresses in the substrate surface region contribute also to the improved fatigue resistance of working tools. Surface stresses in tool steels are usually produced by shot peening what results in an increased resistance to crack initialisation and propagation. Cyclic thermal treatment of working tools results in the fatigue of both the substrate and the coating what negatively influence their lifetime.

In the present study uncoated and CrN coated surfaces of shot peened steel were thermally cycled in home laboratory using a laser beam. Subsequently, the changes in the residual stress state in the coating and in the steel were evaluated using the system MAXIM [8, 9] at the beamline G3. Additionally, a temperature-dependent experiment at 25 and 450 °C was performed whereby the local distribution of the stresses in the coating was evaluated.

![Residual stress distribution](image)

**Figure 1:** Residual stress distribution (right) in uncoated shot-peened steel (left). The surface was 10000 cycled in the temperature range 100-650°C using a laser beam with the diameter 1.5 mm.
On the left side of Figure 1, a scanning electron image (SEM) of the laser beam heated spot is shown. Aside, an image shows the position resolved stress distribution. The stress distribution clearly shows axial symmetry whereas there are radial and tangential cracks in the steel substrate within the laser beam heated spot. The laser beam heating fatigued the steel surface, initialized cracks and diminished the compressive stresses in the spot area. The results can be used to understand the high temperature fatigue behaviour of steel substrates. In the future, such results will be used to determine conditions for simulations to improve high temperature fatigue behaviour of nitride coatings.

Figure 2: Residual stress $\sigma$ as function of position $x$ in CrN coating on shot-peened steel. The blue graph shows the residual stress at room temperature, the red graph shows the residual stress at 450°C.

In Figure 2 the residual stress in a CrN coating at room temperature and at 450°C is plotted as function of distance $x$. The data shows the change in residual stress from room temperature to evaluated temperatures along the distance $x$.

References