Neutron imaging characterization of functionally graded structures built by laser powder bed fusion

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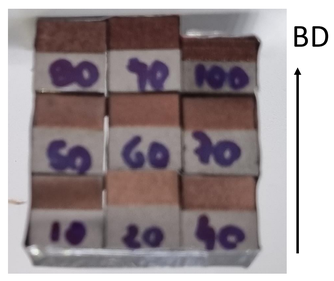
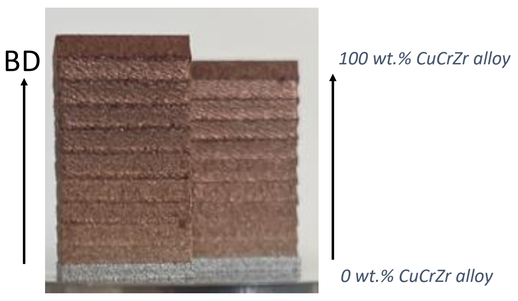
316L-CuCrZr compositionally functionally graded structures

- Multiple 316L-CuCrZr premixtures were prepared with a step of 10 wt.% CuCrZr, employing the TURBULA powder blender mixer
- Two set of samples were printed using SISMA MySint (λ=1070 nm, Pmax=200 W, spot size=55 μm)

Material	Laser Power (W)	Hatch Distance (μm)	Scanning Speed (mm/s)	Layer Thickness (μm)
316L	125	80	750	30
Copper Mixtures	200	90	600	30

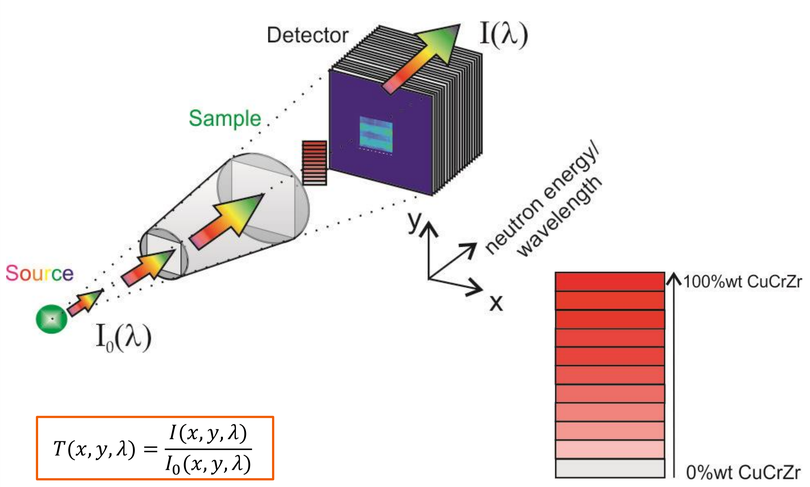


~1 cm x 1 cm x1cm cubes half of each consisting of 316L stainless steel and the other half of 316L and CuCrZr pre-mixtures

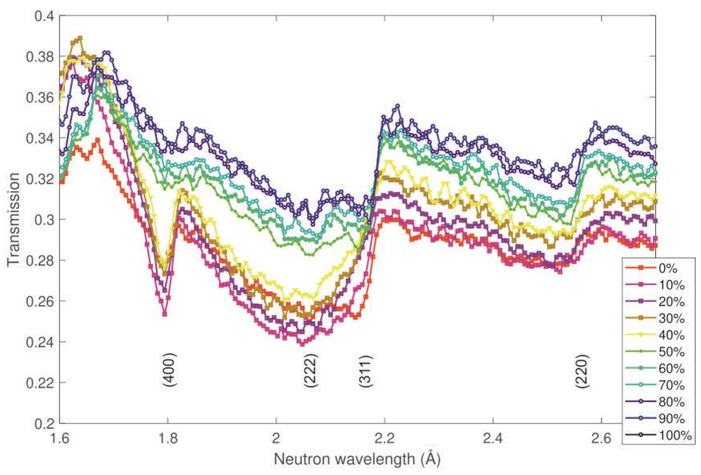


~1 cm x 1 cm x1,5 cm layered structure with gradual compositional changes

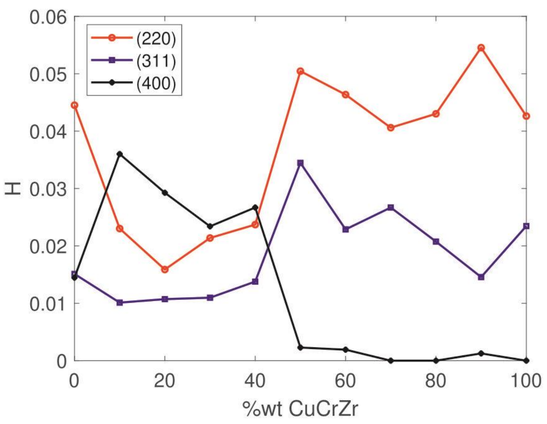
Bragg edge imaging characterization



$$T(x,y,\lambda) = \frac{I(x,y,\lambda)}{I_0(x,y,\lambda)}$$



Transmission spectra for different 316L-CuCrZr composition



Bragg edge heights as a function of the %wtCuCrZr composition in the premixtures

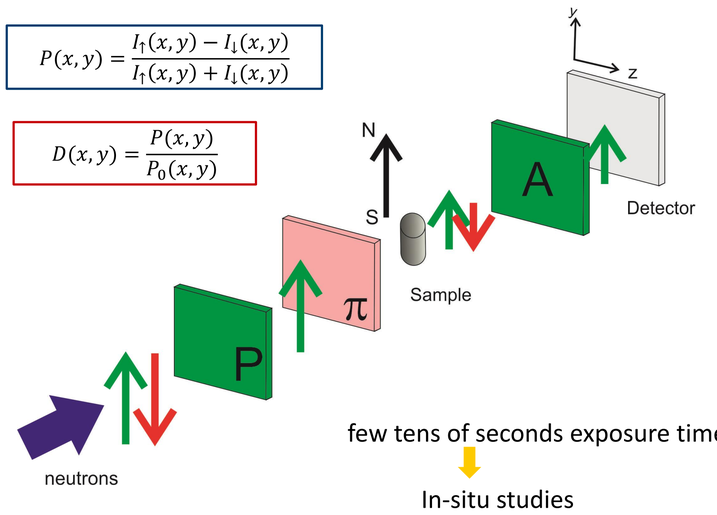
The changes in the Bragg edge height is associated to changes in the crystallographic texture

Strong crystallographic texture change at 50%wtCuCrZr

Polarization contrast neutron imaging

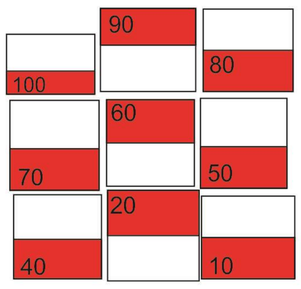
$$P(x,y) = \frac{I_\uparrow(x,y) - I_\downarrow(x,y)}{I_\uparrow(x,y) + I_\downarrow(x,y)}$$

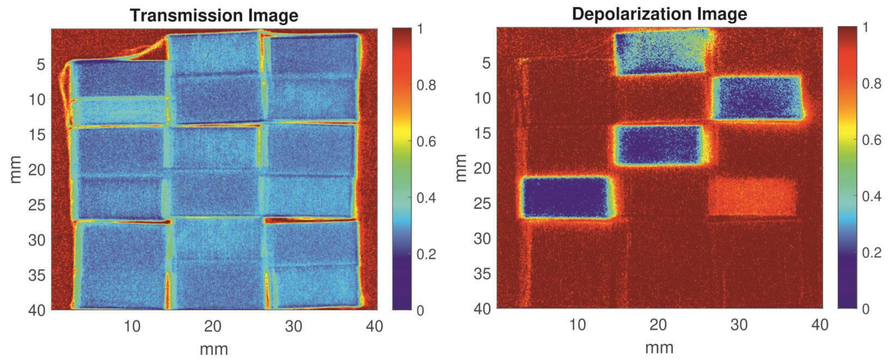
$$D(x,y) = \frac{P(x,y)}{P_0(x,y)}$$



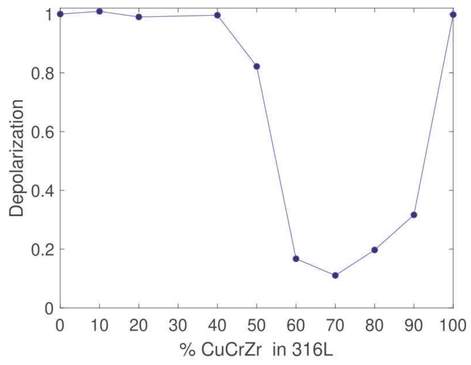
few tens of seconds exposure times

In-situ studies
Tomography





Attenuation and depolarization contrast neutron images.



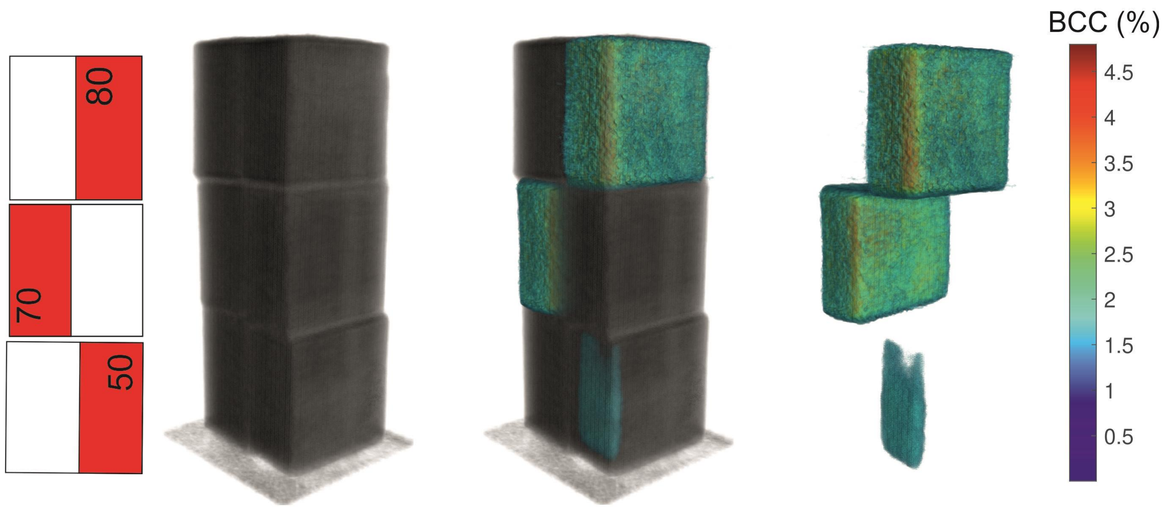
The contrast on the depolarization image is related with different BCC phase fractions

BCC phase > 40%-50% CuCrZr

Max BCC phase = 70%-80% CuCrZr

In agreement with Thermodynamic Simulations

Tomographic reconstruction



Attenuation contrast

Attenuation contrast+ BCC

BCC

Polarization contrast neutron tomography enables the 3D mapping quantification of magnetic phases

We studied LPBF-built samples consisting of 316L stainless steel and 316L-CuCrZr mixed at different wt.% ratios, employing Neutron Bragg Edge Imaging to characterize crystallographic texture distributions across the interfaces and polarization contrast neutron imaging to map the formation of ferrite (BCC), attributed to the diffusion of Ni (austenite stabilizer) from steel to copper.