

## Laser Direct Grain Writing.

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Laser melting the surface of 304 stainless steel allows controlled grain growth in the direction of the laser scan [1]. We demonstrate the application of laser surface melting as a one-step technique for security marking and single crystal grain refinement in metals via localised grain nucleation.

Irradiating the surface of steels with a continuous wave laser forms grain patterns in their microstructure corresponding to the surface melt, independent of the surface quality. In this work, the depth of localised grain nucleation counted  $\sim 20\ \mu\text{m}$ , making hidden messages in the bulk of the material possible after mechanically removing the immediate surface melt. The patterns are undetectable by conventional optical microscopy but can be viewed with differential interference contrast (DIC) microscopy or grain imaging techniques (focused ion beam, electron backscatter diffraction), this way establishing a metal security marking technique.

For single crystal grain refinement in steels, the results show single crystals after three consecutive passes with constant laser parameters throughout the length of the laser raster at  $19.17\ \text{kJ}/\text{cm}^2$  average energy density by a continuous wave non-polarised fibre laser with a wavelength of  $1.064\ \mu\text{m}$  at 300 K, 0.1 % oxygen environment.

[1] Gortat, D., Murray, P.T., Fairchild, S.B., Sparkes, M., Back, T.C., Gruen, G.J., Cahay, M.M., Lockwood, N.P., O'Neill, W., 2017. Laser surface melting of stainless steel anodes for reduced hydrogen outgassing. *Mater. Lett.* 190, 5–8.