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 grain refinement, security marking and electrical conductivity increase 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 ~20 μm, 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 grain refinement and electrical conductivity increase in steels, the results show single crystal generation after three consecutive passes with constant laser parameters throughout the length of the laser scan and ~40 % increase in electrical conductivity after a single bidirectional laser raster scan with a 36 % line overlap at 19.17 kJ/cm^2 average energy density by a continuous wave Yb fibre laser with a wavelength of 1.064 μm.

[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.