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C2-WED-AM2-2 - Influence of Surface Roughness on the Formation of Laser Induced Periodic Surface Structures (LIPSS) in Copper

C2. Laser-based Processing and Manufacturing

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Introduction/Purpose

The generally accepted mechanism leading to LIPSS formation relates to the interference of incident laser light with a wave propagating at the surface, leading to a periodic intensity modulation that is imprinted into the material [1,2]. Amongst the irradiation parameters, the angle of incidence (tetha) of the laser beam directly influences the period of the so-called Low Spatial Frequency (LSF) LIPSS (parallel ripples perpendicular to the laser polarization).

Here, we report a strong deviation of the angle dependence of the LIPSS period on Cu from the predictions of existing models based on Surface Plasmon Polariton (SPP) propagation, and correlate it to the strong dependence of the SPP wave-vector on surface roughness [3,4].

Methods

LIPSS in Cu where formed upon irradiation with 120 fs laser pulses at 800 nm at different angles of incidence and effective number of pulses per unite surface.

Results

Fig. 1(a) shows a SEM image of LIPSS in Cu formed upon irradiation at a fixed angle of incidence (theta= 52^{o}). The periodic structures are aligned perpendicularly to the laser polarization. Notably, two different ripple periods are observed in different regions of the laser-written track. Fig. 1(b) shows in direct comparison of modelling results taking as an input the specific surface roughness of the exposed regions measured with atomic force microscopy.

In order to explain such differences, we introduce a model incorporating the strong dependence of the SPP´s wave-vector on surface roughness parameters [3,4]. Fig. 1(c) shows the periods of the two types of ripples for different angles of incidence, combining the experimental data with the results of our model.

Conclusions

The model fits the experimental data very well for all angles, much better than the simple plasmonic model not taking into account the surface roughness, which highlights the potential of our model for the general understanding of LIPSS in metals.

Selected references

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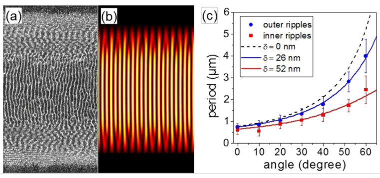

Fig. 1. (a) SEM image of LIPSS in Cu upon exposure to Neff = 1000 fs laser pulses at 52º angle of incidence. (b) Field intensity distribution of SPPs propagating on areas of different surface roughness calculated by our model. (c) Dependence of the ripple period for the two types of ripples in Cu with the angle of incidence. The symbols correspond to experimental data, whereas the solid curves represent the result of our model and the dashed curve corresponds to the result of the standard model.