Broadband pump probe setup for ultrafast transient reflectivity measurements

Hendrik M. Wrigge[1*], Pascal D. Ndione[2], Bärbel Rethfeld[2], Peter Simon[1]

[1] Institut für Nanophotonik Göttingen e.V., Hans-Adolf-Krebs-Weg 1 37077 Göttingen, Germany
[2] Department of Physics and OPTIMAS Research Center, RPTU Kaiserslautern-Landau, Erwin-Schrödinger-Straße 46, 67663 Kaiserslautern, Germany
[*]Corresponding author email: hendrik.wrigge@ifnano.de

The irradiation of solid materials with energetic ultrashort laser pulses leads to the generation of highly excited non-equilibrium states. Their detailed investigation provides a deep insight into the mechanisms of light-matter interaction. A better understanding of the processes involved is the basis to control the material changes taking place and thus, for instance, improving the quality of material processing. To get access to transient optical parameters of the highly excited material, a broadband, time-resolved pump-probe setup is realized, allowing to capture the reflectivity of the irradiated material surface with a high temporal resolution of ~10 fs. This procedure enables spectrally resolved investigation of the transient states, below and above the ablation threshold.
For the measurements, the output of a Ti:Sa laser system emitting 80 fs long pulses is split into two beamlines. The pump beam passes a delay line and is directed to the sample. The fundamental IR pulse (~780 nm) or its second harmonic (~390 nm) can be used for excitation. The probe beam (carrying ~10% of the laser output) is launched into a two-stage cascaded hollow fiber compressor which increases the bandwidth to ~ 550 nm-900 nm and reduces the pulse duration to less than 10 fs.
The performance of the setup is demonstrated by measuring the time resolved reflectivity of bulk gold samples. The transient energy deposition of the pump pulse and the reflectivity of the probe are simulated using a two-temperature model and a modified Drude-Lorentz approach [1]. The experimental results are compared with the simulations. This comparison reveals the importance of considering the transient values of the reflectivity during the excitation phase. Thanks to the flexibility of the experimental apparatus, further measurements could also be carried out on semiconductors such as Si and other materials.

[1] P. D. Ndione, S. T. Weber, D. O. Gericke, B. Rethfeld ArXiv:2307.11874 (2023)