Femtosecond heterodyne pump probe Platform.

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We present a femtosecond instrumentation platform using a heterodyne pump probe technique. With this technique a laser pulse called "Pump" interacts with the surface of the sample. This leads to thermal perturbations and acoustic phenomena. The subsequent reflectivity modifications are measured by a low-power second laser pulse called "Probe". Varying the time difference between the "Pump" and the "Probe" allows the measurement of the reflectivity evolution. With the homodyne pump-probe technique [1], a unique laser beam is split in two with a mechanical delay line to adjust the time difference but generates instabilities. Whereas the heterodyne pump-probe scheme [2] exploits two lasers with a small shift in the repetition frequency and allows better signal noise rate.

In our experimental setup, we use Ytterbium lasers (with a wavelength λ of 1030 nm) designed by AMPLITUDE SYSTEMS. The pulse width is 150 fs and the repetition rate is 48 MHz. Second Harmonic Generation (SHG) crystals can be added to one or the two lasers beams. "Pump" and "Probe" beams are cross polarized to separate them later. The two lasers are electronically synchronized with a controlled frequency shift generated by a Direct Digital Synthesizer (DDS). The coincidence between the "Pump" and the "Probe" is determined thanks to a two-photons (λ = 1030 nm) absorption with a GaAsP photodiode (sensitive to λ = 515nm). A sharp pulse is then generated and allows the determination of the jitter of the frequency shift. Currently, the jitter of our setup is less than 1ps.

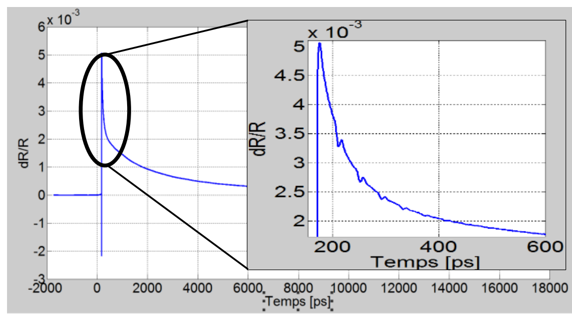

Fig. 1: Typical thermoreflectance signal on a Si substrate with a layer of 100 nm of tungsten (W).

Pump-probe techniques permit thermal and acoustic picosecond characterizations [3]. In figure 1, we can see a typical thermoreflectance signal of a 100 nm thick layer of tungsten on a silicon substrate. On the left side, we observe the thermal response giving information on the thermal conductivities of the W layer and Si substrate. Acoustic echoes are visible on the right side. Sound velocity of the W layer can be calculated from their period.

The main goal of this instrumentation plateform is to provide an instrument to fulfill a need in the field of thermal characterization at short space and time scales, allowing locally characterize thermal conduction in nanomaterials at sub-micron spatial and sub-picosecond temporal resolution, for many applications in fields such as microelectronics and nanomaterials. With this platform, we can have access to short time phenomena (our temporal resolution is 1 ps). Thanks to motorized lenses, surface acoustic wave propagation can be imaged. To improve the spatial resolution, we combined a solid immersion lens (SIL) to the pump-probe heterodyne setup.

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