COMSOL Multiphysics® Based Identification of Thermal Properties of Mesoporous Silicon By Pulsed Photothermal Method

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Abstract

The silicon is mainly known under its single-crystal shape and polycrystalline. Since a few decades, a new type of morphology is developed: the porous silicon (p-Si). Meso-porous silicon (Mp-Si) is one of promising materials for future microelectronic chips multi-functionalization systems, and for micro-sensing devices [1].

More particularly we are interested by the study of the thermal properties of those materials versus the specific morphology (porosity rate, and pore sizes). There are various analytical models that allow the thermal conductivity prediction, function of the porosity rate and the conductivities of the 2 phases (silicon and air). But those models are often based on a barycenter approach far from the real microstructure. That's why the modelling in COMSOL Multiphysics® is interesting to simulate the heat transfer in multi-layer geometries in 2 or 3 dimensions.

For thermal properties investigation many experimental systems were developed based on the photothermal effect [2]. One of typical way is to induce a rapid surface temperature increase using pulsed laser beam acting like a heat source (volume or surface depending on the absorption coefficient) to finally create a model of this interaction. At least, it will be possible to determine the thermal parameters using the identification method (optimization by the least squares for example).

Reference

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Figures used in the abstract

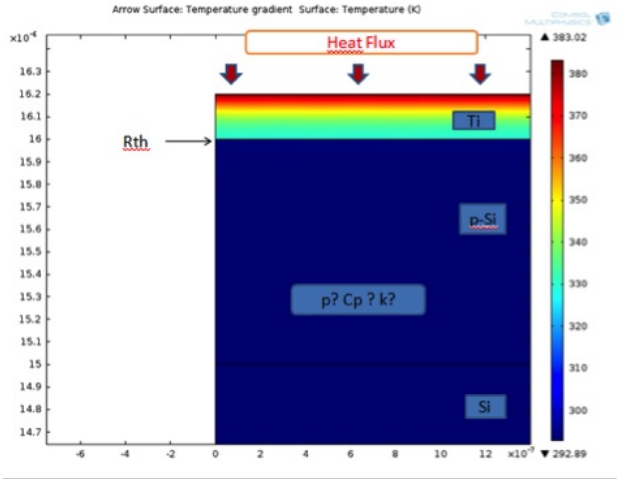

Figure 1: Figure 1 : View of the multi-layers sample for 1µm etched depth

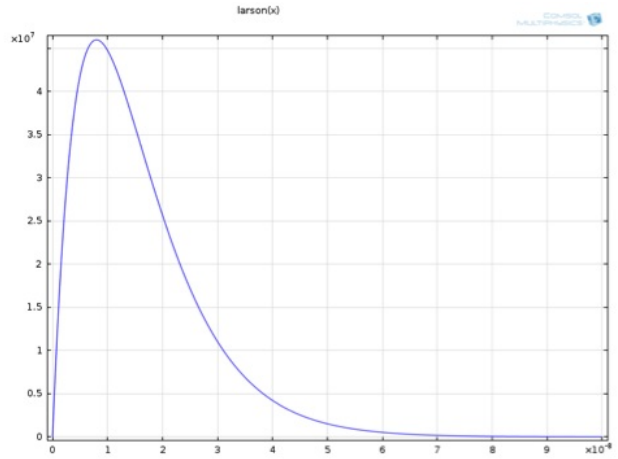

Figure 2: Figure 2: 'Larson' pulse time distribution

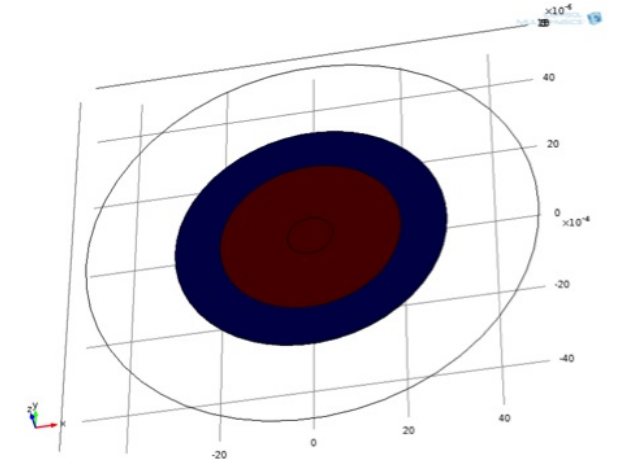

Figure 3: Figure 3: Top sight of our sample with laser spot (in red)

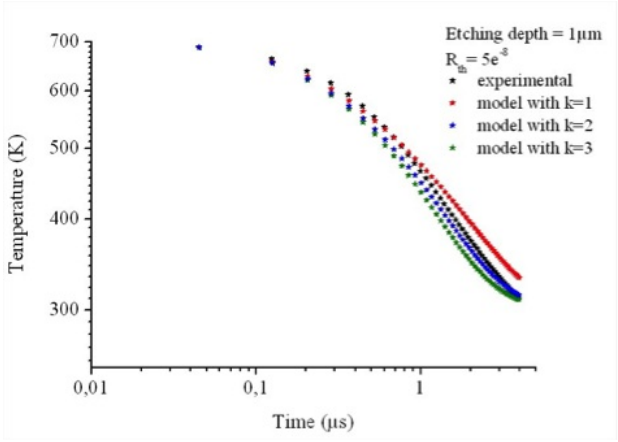

Figure 4: Figure 4: Surface temperature for 1µm (1) and 0.2µm depth etching (2) in log/log scale