Investigation of Ultrafast Carrier Dynamics in Scandium Nitride (ScN) Using Pump-Probe Time-Resolved Spectroscopic Ellipsometry

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In the rapidly advancing field of semiconductor technology, scandium nitride (ScN) shows significant potential as a wide bandgap semiconductor (up to 2.6 eV) [1] with versatile applications in high-power electronics, optoelectronics, and photovoltaics. This study investigates the transient dielectric function (DF) of ScN after it is excited with a pump beam, using time-resolved spectroscopic ellipsometry (trSE). The time resolution of the method is 8 fs and a measured delay of up to 5 nanoseconds. We successfully measured the spectrum from 1.5 to 3.8 electron volts. Fig.1. illustrates the change in the imaginary part of the dielectric function (ε_2) when ScN is excited with a pump beam with energy higher than the gap energy of 4.66 eV.

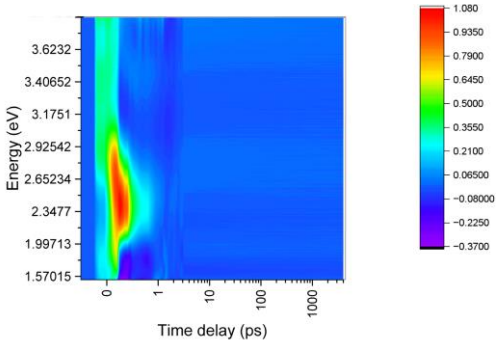

Fig.1. Heat map of the change in the imaginary part of the dielectric function after excitation much higher than the gap energy

We modeled the experimental data by B-spline interpolation to uncover the temporal evolution of the DF.

Our findings reveal significant transient changes in the DF, offering profound insights into the intra-band and inter-band dynamics of ScN and its electronic structure. We interpret the dynamic features we found in the DF compared to band structure data found in literature as follows: First, we note durable characteristics linked to Drude oscillations and electron mobility, indicating these oscillations and the movement of charge carriers are sustained longer than usual, particularly when compared to the quick recombination of freshly excited carriers. This suggests efficient energy retention and delayed electron-hole pair recombination. Second, following the initial excitement of electrons from one energy band to another, we detect transient activity within the conduction band, spurred by the flat conduction band minima at the band structure's X, W, and K points. This uniformity appears to mitigate the effects of Pauli blocking, allowing for an unusual accumulation and subsequent excitation of electrons.

References

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