# Temperature Kinetics during Catastrophic Optical Damage of Diode Lasers

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Catastrophic optical damage (COD) represents a generic sudden degradation mechanism of diode lasers under high optical load. The process starts at a microscopic ignition site (<1 $\mu$m) and becomes macroscopic (10-100 $\mu$m) on a nanosecond timescale. The peak temperature $T_{max}$ of the defect front and the temperature kinetics during the defect expansion have been subject to extended speculations in the past.

We applied different experimental approaches in order to clarify this:

- The motion of the defect front was analyzed in situ with micro-thermography.
- The signal amplitudes of the thermal flashes of Planck's radiation related to the COD were modeled by thermal transients, the boundaries of which are set by experiments.
- The technique being used to provoke the COD in single pulses allowed preparing very early stages of defect evolution. Moreover, in this way the energy incorporated into defect creation is known. Thus, reliable energy balance calculations became possible.
- Transmission electron microscopy (TEM) pictures have been taken at very early defect evolution stages. A crystallographic interpretation of the defect pattern allowed for an estimation of the involved temperature kinetics.
- The modeling of the heat spread during macroscopic defect growth within the device gave further information on the temperatures during defect propagation.
- A comprehensive model of the macroscopic defect spread fully explains the experimental results.

The experiments with AlGaAs/GaAs based quantum well diode lasers emitting around 808 nm indicate that $T_{max}$ amounts to ≈1500°C. Furthermore, the data point to a very rapid heating/cooling thermo-cycle, which allows no thermodynamic equilibrium state of the re-crystallizing semiconductor melt. Fig. 1(a) shows a TEM image of a sample damaged by COD starting at the front facet marked by the arrow. The direction of epitaxial growth is along the y-axis; z gives the resonator axis. Dendrites are visible as inhomogeneities in Fig. 1(b), representing the area marked in Fig. 1(a) on an expanded scale. This indicates a non-equilibrium re-crystallization of the molten material typical for fast processes.

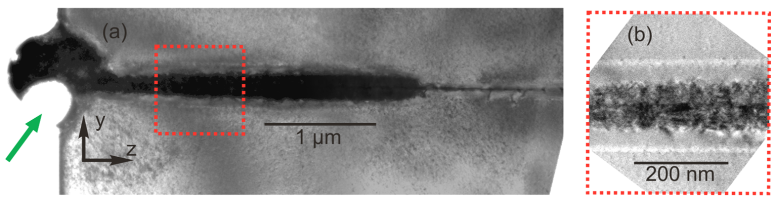


Figure 1: (a) TEM image of a diode laser damaged by COD starting at the front facet indicated by the arrow. (b) Region indicated by the red dotted rectangle in (a) on an expanded scale.