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# Sample Preparation of Fully Packaged Quantum Well Laser Diodes for STEM-EBIC Analysis

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Simultaneous acquisition of the structural, chemical, and electrical properties of semiconductor samples can be acquired using Scanning Transmission Electron Microscopy (STEM) analysis, provided it is equipped with an Electron Dispersive Spectroscopy (EDS) detector and an Electron Beam Induced Current (EBIC) system. In this work, a novel sample preparation technique has been designed to allow for STEM-EBIC analysis of fully packaged laser diodes (LDs). While other preparation techniques have been developed for STEM analysis, they are not well adapted to the preparation of fully packaged LDs that require the integrity of their electrical contacts to be maintained throughout preparation [1]. The sample preparation of these fully packaged LDs is divided into several steps, including mechanical thinning, grid and wire attachment, and Focused Ion Beam (FIB) milling to create an electron transparent membrane. This technique allows for a thinned electron transparent region of interest while still maintaining a thick specimen for mechanical stability and electrical contacts for the EBIC analysis.

The samples chosen to illustrate the new technique are fully packaged 5.6 mm commercial AlGaInP index guided MQW devices with wavelengths ranging between 635-670 nm. Initially, the packaged LD is exposed and the p-n junction location of the device is determined by SEM-EBIC (FIG. 1). The device is mechanically thinned to an apex of $<25\mu m$ (FIG. 2) and sandwiched between two Cu grids. One grid makes electrical contact to the submount and the other grid makes electrical contact to the Au wire while still maintaining electrical isolation between the top and bottom of the device (FIG. 3). The final step involves Focused Ion Beam Micromachining (FIBM) of an electron transparent membrane approximately 100nm thick in the active region of the device. Utilizing this new technique the FIBM time was reduced by 50% over previous methods applied to fully packaged LDs [2]. The introduction of this novel sample preparation method using a variation of the tripod wedge method in combination with the FIB technique has proven to be successful in the preparation of these samples for cross-sectional STEM-based analysis. This unique preparation coupled with the appropriate sample holder makes the nano-characterization of structural, compositional, and electrical properties of semiconductor materials and devices possible.

[1] C. Cabanel et. al., *Philosophical Magazine Letters* 79 (No. 2) (1999), 55-61.
[2] K.L. Bunker et. al., '*Current Issues on Multidisciplinary Microscopy Research and Education*', Vol. 2, edited by A. Méndez-Vilas: (FORMATEX, Badajoz, Spain), in press.

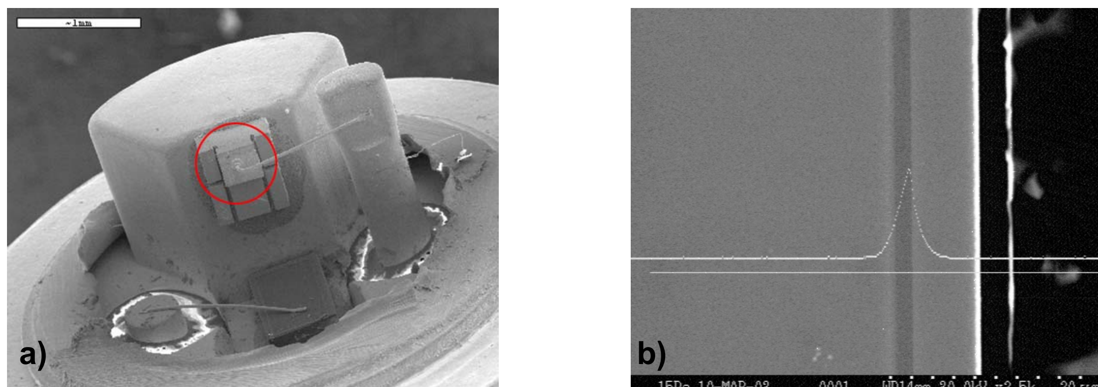


FIG. 1 a) SEM micrograph of packaged LD with cap removed showing the area of interest (red circle). b) SEM-EBIC line scan overlaid on secondary image showing the location of the active region relative to the surface of the device.

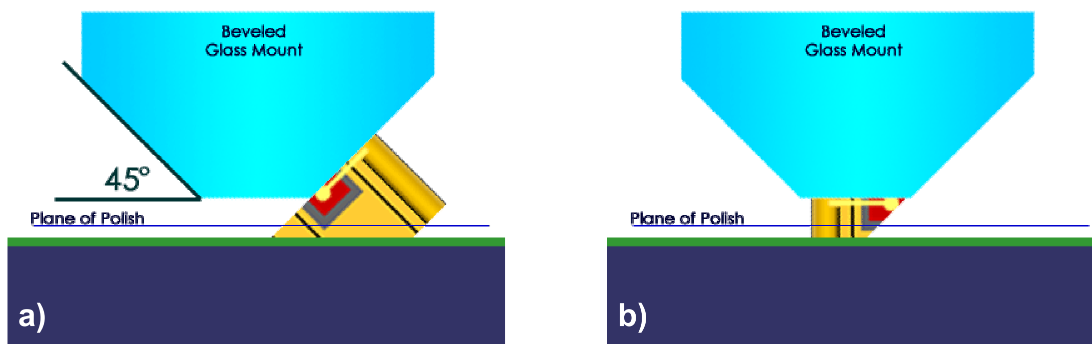


FIG 2. Schematic of mounting and grinding orientations for sample preparation. a) Sample is polished at 45° angle. b) Sample is thinned for placement onto Cu grids.

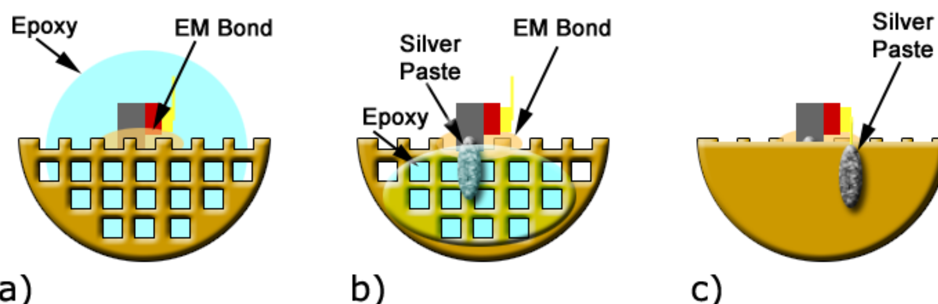


FIG 3. Schematic of mounting procedure. a) Specimen is glued to first grid. b) Electrical contact is made between first grid and substrate and an insulating layer of epoxy is spread on top. c) Second grid is placed on top and conductive path is made from gold wire on LD to grid.