Workmanship Standards for High Power InP-based Diode Lasers

The following note is to help partners and customers to understand the importance and the purpose of the workmanship standards for high power laser diodes of Indium Phosphide (InP) based material. It can be used to facilitate a successful operation with visual inspection of a semiconductor laser chip or bar. Areas to be covered by this note are:

- Manufacturing of InP-based Semiconductor Laser
- Cosmetic defects or contaminations
- Importance of the workmanship standards and examples

Manufacturing of InP-based Semiconductor Laser

InP is an important III-V compound semiconductor used in photonic and high-speed electronic devices such as lasers, LEDs, photodetectors, and modulators. It is the sole material for the high-power edge-emitting laser diodes of near to short-wavelength IR from 1200nm to 1700nm. They are crucial for communications, military, medical, sensing and LiDAR applications. Although it has been well studied and researched since its inception several decades ago, InP-based wafer manufacturing for high power edge-emitting laser diodes is still the most difficult and challenging among all commercial devices.

To successfully fabricate an edge-emitting InP-based laser diode, it is required to master its complete processes from the ground up including epitaxial growth, photolithography, wafer thinning and polishing, metallization, bar cleaving, facet mirror coating, chip dicing, etc. Every stage contains multiple steps critical and challenging in their own way for achieving the targeted performance and long-term reliability. It is most important to note that InP-based wafer material is much more fragile and brittle compared to other laser material such as GaAs, and can be easily damaged, scratched and contaminated with debris throughout the process. Thus, common workmanship standards for GaAs often differ from InP standards and defects that may be attributed to GaAs material, may be acceptable for InP material.

Cosmetic Defects or Contaminations

InP laser diodes can only be processed out of wafers in 2”, 3" or 4" diameter with intensive manual operations involved. For examples just to name a few, oftentimes an operator needs to:

- hand hold a tweezer to pick up a wafer coated with a thin metallization film,
- pick up a fragile bar of only a few hundred microns wide,
- painstakingly stack one bar after another onto a mechanical jig for facet coating, and
- use a machine tool to transfer a small die from one stage to another.

During these manual steps, cosmetic defects such as scratches and contamination could easily occur. As a result, the process and variation control from one wafer lot to the next continues to be extremely difficult. For a successful operation there are challenging processes and training involved.

Importance of the Workmanship Standards

It is our mission at SemiNex to deliver high-quality laser diodes to the marketplace. We have established a methodology to manage the manufacturing processes and continue to deliver abundant laser diode products with high performance and reliability. We possess the know-hows

of making InP-based laser diodes and focus on the critical parameters that need to be thoroughly controlled and monitored.

As we strive for perfection, cosmetic defects are common and unavoidable in devices of InP-based material as mentioned. We have accumulated decades of industrial experience of laser manufacturing and applied the advanced knowledge into our daily practices and the workmanship standards. By thorough visual inspection based on the workmanship standards, we can identify cosmetic defects and also clear out any defects might impact performance and reliability. Thus the high quality laser diodes can still be offered to our customers with affordable pricing at the same time.

The major areas included in the workmanship standards are

- Exterior defects on the device
- Contamination or debris on the metallization
- Defects and overspill on the facet mirror coatings

As most of the defects or contaminations are outside the lasing aperture or active waveguide area, some of them might fall into the active regions. The workmanship standards call out the allowed sizes when the ratio of the defects to the active area is insignificant and negligible. Below are some basic rules of thumb to identify cosmetic defects and contaminations that are considered within the workmanship specifications.

- Chipping less than 50μm in the corner of a chip or bar has no effect on the lasing modes and the subsequent soldering process is within specs, as shown in Fig.1.

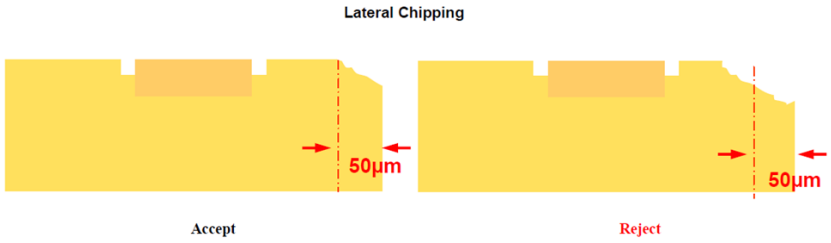

Fig. 1

- Contaminations or debris smaller than 50μm on the N or P-side metallization or outside the waveguide area are considered within specs, as shown in Fig.2.

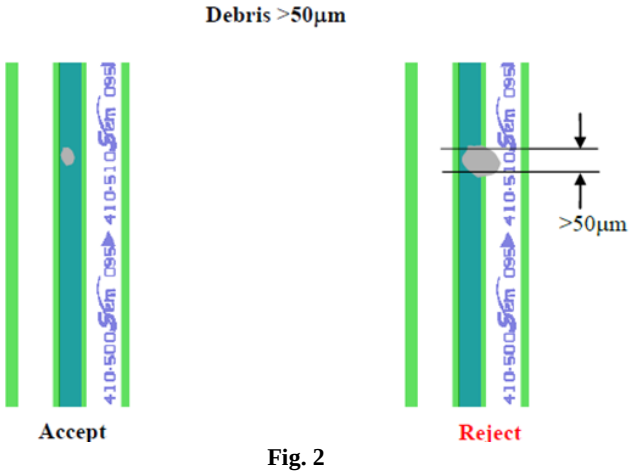

Fig. 2

- Inhomogeneous spot smaller than 1.5μm on the facet mirror coating or outside the lasing aperture is considered within specs, as shown in Fig.3.

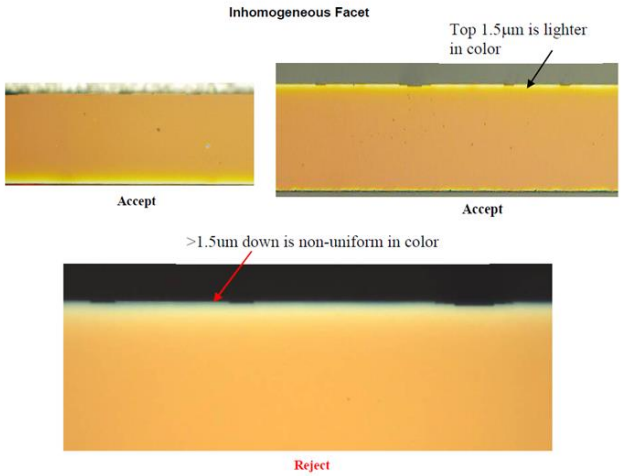

Fig. 3

- Mirror coating overspill less than 15μm on the P-side or less than 30μm on the N-side is considered within specs, as shown in Fig.4.

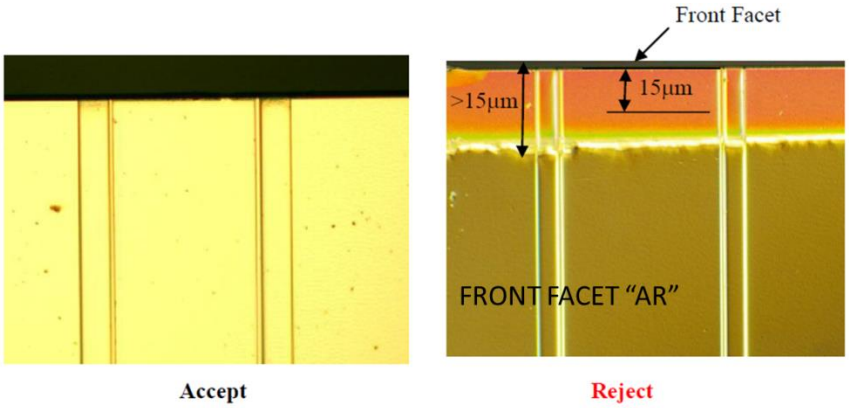

Fig. 4

- Crystal step or striation on facet outside the lasing aperture and the active waveguide region is considered within specs, as shown in Fig.5.

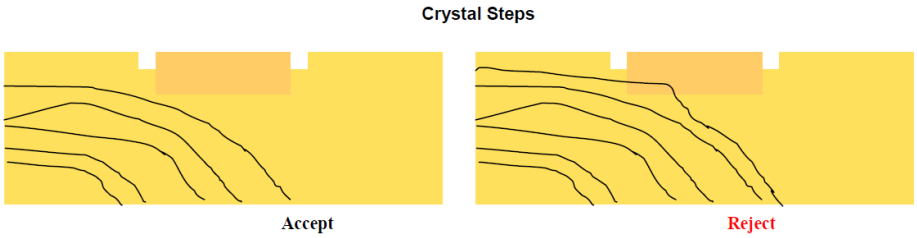

Fig. 5

In summary, SemiNex works closely with partners and customers to ensure that no quality is compromised. When all parties understand and follow the same methodology and implementing

the workmanship standards properly, we can all achieve the desired outcome for our applications and business satisfaction. The SemiNex team being your trustworthy partner and supplier is here to work with you, and bring the best out of the high-power laser diode technologies for your success.

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