Application Note

Contrast enhancement of polished cross sections of semiconductor structures

Sample Preparation for SEM related instrument Leica EM RES102
**Contrast enhancement of polished cross sections of semiconductor structures**

**PROBLEM**
The surfaces of polished cross sections often show fine scratches and residues of the removed material or of the abrasive material. The artefacts are strongly material-dependent, and are mostly only detectable at higher resolutions in the scanning electron microscope. A further problem arises from the fact that the ground section mostly only has low contrast, i.e., the structures of the semiconductor materials are very difficult to discern. Conventionally, the surfaces of the ground sections are wet-chemically etched to improve the contrast. As a result, specific acids are required for each material system.

With the use of ion beam milling, the ground sections of semiconductor structures can be „contrasted“.

**PREPARATION CONDITIONS**
The ground sections were cleaned and selectively milled with the help of ion beam milling process. In doing this, various milling angles and times were tested.

- **Acceleration voltage:** 6 kV
- **Milling angle:** 15° and 90°
- **Milling time:** variable
- **Sample movement:** rotation

**RESULTS**
The surface of the sample was cleaned and lightly selectively milled with a milling angle of 15°. To obtain efficient contrasting, however, the sample has to be milled at a steeper angle. A significant increase in the contrast of the structure was, however, only achieved after an additional ion milling at 90°. The milling time required is dependent on the material combination and the task in hand, and so must be determined for each different preparation problem.
SEM images of the cross-section after cleaning (15°) and contrast enhancement (90°)

SEM image of the cross-section after (15°) and selective milling (90°) with clearly visible grain structure of the W Plug.
**Au wire bond (45 min polishing, 3 min contrast enhancement):**

**PURPOSE**
The gold wire bond looks perfect after ion polishing. The grain structure of gold and the structure of the bond area are visible (Fig. 1). Nevertheless, an additional contrast enhancement step can expose the fine structure like intermediate layers.

**PREPARATION CONDITIONS**
1. Polishing:
   - Acceleration voltage: 6 kV
   - Gun current: 2.2 mA
   - Sample movement: Oscillation ± 60°
   - Milling angle: 6°
   - Milling time: 45 min

2. Contrast enhancement
   - Acceleration voltage: 3 kV
   - Gun current: 1.6 mA
   - Sample movement: Oscillation ± 60°
   - Milling angle: 35°
   - Milling time: 6 min

**RESULTS**
Fig. 2 shows the result of the short contrast enhancement step. Now the inner structure of the bond area is clearly visible.

![Fig. 1: Au wire bond after ion polishing](image)
Fig. 2: Au wire bond after polishing and contrast enhancement
**Cu wire bond (1h 45 min polishing, 3 min contrast enhancement):**

**PREPARATION CONDITIONS**

1. Polishing:
   - Acceleration voltage: 6 kV
   - Gun current: 2.2 mA
   - Sample movement: Oscillation ± 60°
   - Milling angle: 6°
   - Milling time: 1 h 45 min

2. Contrast enhancement:
   - Acceleration voltage: 3 kV
   - Gun current: 1.8 mA
   - Sample movement: Oscillation ± 60°
   - Milling angle: 35°
   - Milling time: 5 min

Cu wire bond (1 h 45 min polishing, 5 min contrast enhancement)
Cu wire bond (1 h 45 min polishing, 5 min contrast enhancement)
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