Application Note RSMD-20220728

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Measurements of AgSn micro solder bump using monochromatic micro X-ray beam

WLP Bumping / Device wafer

Introduction

As the industry advances, electronic devices are becoming increasingly miniaturized and compact. As part of this scaling, conventional solder bumps are being replaced by more advanced bumps, such as solder bumps on copper pillars.

Copper pillar bump is widely used for many types of flip-chip interconnects, which offers advantages in many designs while meeting current and future ROHS requirements. It is an excellent interconnect choice for applications such as transceivers, embedded processors, application processors, power management, baseband, ASICs and SOCs.

Problem statement

The polycapillary limitations for low concentration Ag detection and analysis are due to the low excitation and high background. As copper pillar dimensions are reduced, the amount of Ag decreases. A more sensitive method is required.

Recommended equipment

- Equipment: ONYX 3000
- X-ray beam module: COLORS™-W

Measurements and results

The tool used for this measurement is the Rigaku ONYX 3000, which has a vertical incidence EDXRF (Figure 1).

Figure 1: ONYX 3000 in-line non-destructive wafer inspection and metrology

For the X-ray source and optics, the monochromatic X-ray beam module COLORS-W is applied (Figure 2).

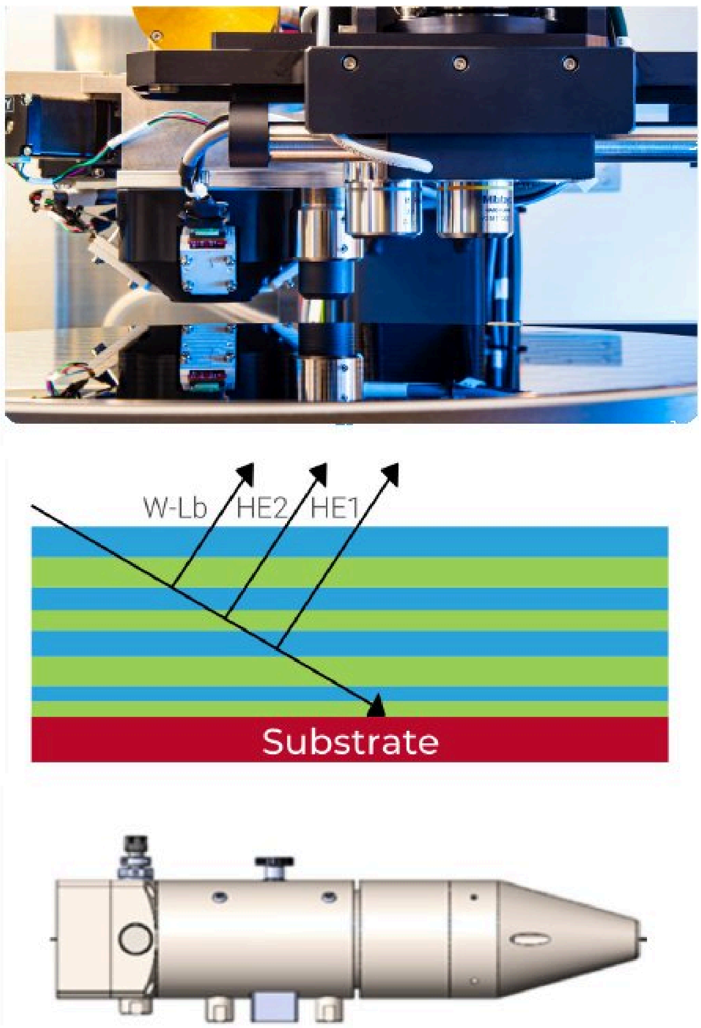


Figure 2: COLORS-W multilayer mirror

The sample | GO3 Type-A

Composition of AgSn solder containing 2.5 wt% Ag is used as the measured sample.

The Ag content in the solder is a significant factor in the properties of the resultant bump, so it is essential to measure the Ag content precisely.

COLORS-W

Features of COLORS-W are shown below.

1. 20 µm FWHM spot monochromatic X-rays (not white X-rays) by multilayer focusing optics
2. Three different energy X-rays in one beam through novel multilayer optics (Figure 3)

- W-Lb (9.67 keV) for copper pillar / under bump metal

- W-HE1 (27.2 keV) for Ag
- W-HE2 (29.6 keV) for Sn

COLORS-W measurement gives similar spot size and excellent repeatability results for Ag/Sn ratio while using lower acquisition time compared to traditional polycapillary optics.

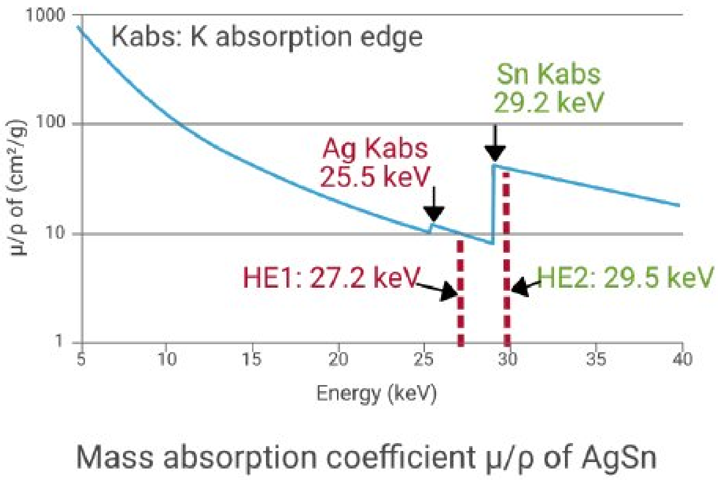


Figure 3: Energies generated by COLORS-W and the K absorption edges of Ag and Sn

Unique solution

Figure 4 and Figure 5 show XRF measurement results of AgSn solder bump with COLORS-W, and with standard polycapillary (white X-rays) as a reference, respectively.

COLORS-W obtains evident Ag and Sn XRF peaks with a very high S/N ratio even though Ag content is very low.

In contrast, the result with polycapillary has a poorer S/N ratio and very high background noise. High S/N with COLORS-W is obtained by tuning the incident beam energy to slightly above Ag and Sn absorption edges, enhancing the signal substantially. Furthermore, the use of a monochromatic beam significantly reduces background noise.

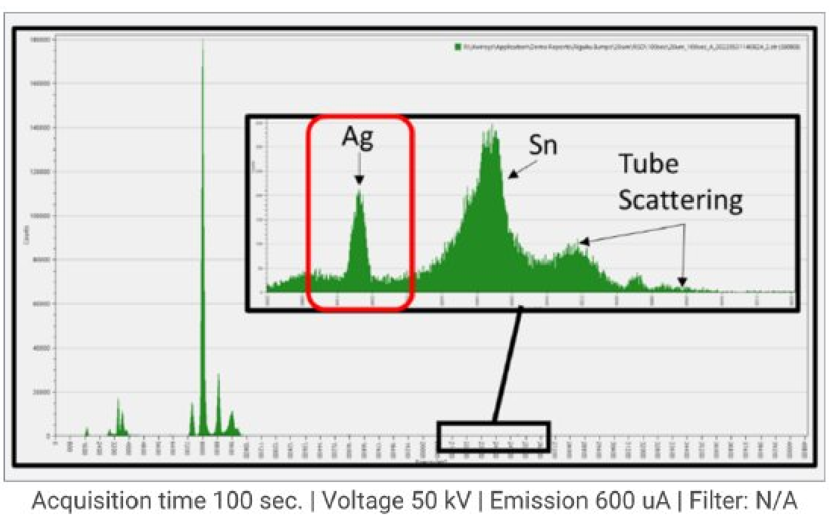
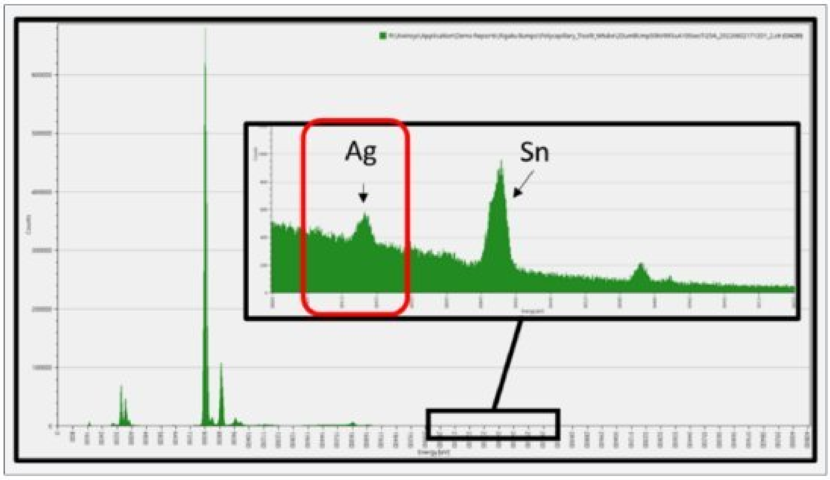


Figure 4: XRF results with COLORS-W

Measurement time vs RSD of XRF intensity with COLORS-W is shown in Figure 6. Good precision can be obtained with an acquisition time of 100 sec or more. Table 1 shows comparison of RSD between COLORS-W and polycapillary optics at an acquisition time of 200 sec. COLORS-W shows an obvious advantage over polycapillary optics in precision.



Acquisition time 100 sec. | Voltage 50 kV | Emission 995 uA | Filter: Ti 75 µm

Figure 5: XRF results with polycapillary

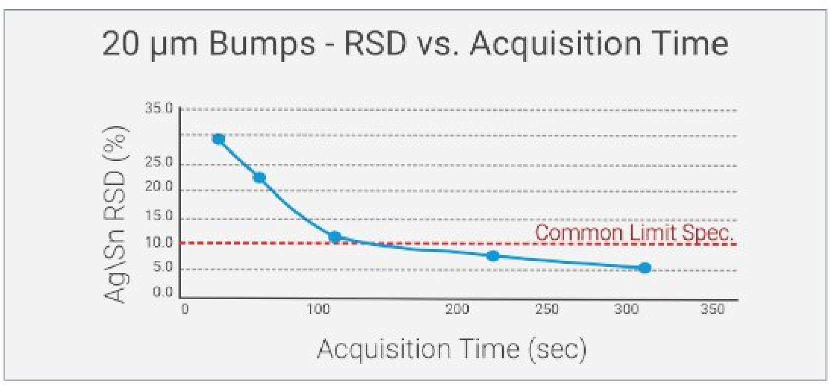


Figure 6: Acquisition time vs RSD

Table 1: RSD (3σ) at 200 sec acquisition time

Optics	Ag RSD	Ag\Sn ratio RSD
COLORS™	**2.2**	**8.3**
Policapillary	27.0	19.0

Related products

ONYX 3000

EDXRF and optical hybrid metrology tool for automated X-ray analysis, 3D scanning, and 2D microscope for film thickness and composition measurements on blanket and patterned wafers for up to 300 mm wafers