

# Interfacial phenomena in Al-Si-Bi system

J. T. Szabo<sup>a,b,\*</sup>, O. Z. Nagy<sup>a</sup>, Z. Harangi<sup>a,b</sup>, P. Baumli<sup>a,b</sup>, G. Kaptay<sup>a,b</sup>

<sup>a</sup> Bay Zoltan Applied Research Nonprofit Ltd, Dept. of Nano-materials, 2 Igloi street, 3519 Miskolc, Hungary

<sup>b</sup> University of Miskolc, Dept. of Nanotechnology, Egyetemvaros, 3515 Miskolc, Hungary

\*jozsef.t.szabo@gmail.com

The interfacial phenomena and the wettability play important role in the fabrication of metallic emulsions and foams. Liquid metallic emulsions are made of two, immiscible liquid metals. Upon intensive mixing one of the liquid metals or both form small droplets dispersed in the matrix of another liquid metal. If the system contains small solid particles of appropriate interfacial properties, the particles will be concentrated at the interface between the two liquid metals, which will lead to stabilization of the liquid metallic emulsion. Stabilization means

that despite the gravity induced separation of the system, the microstructure remains heterogeneous [1-4]. In our work we investigated the behaviour of the bismuth droplet under molten aluminum. The contact angle of the molten bismuth on different solid substrates was measured by sessile drop method. It was found that the bismuth perfectly wetted the aluminium surface. The contact angle of in-situ formed bismuth droplets on the primary silicon crystals in Al-rich matrix was also studied by image analyses on SEM images.

## Theory of stabilization of emulsions and foams

## Motivation: Fabrication of Al-20Si / Bi metallic emulsion

The optimum contact angle required for stabilization

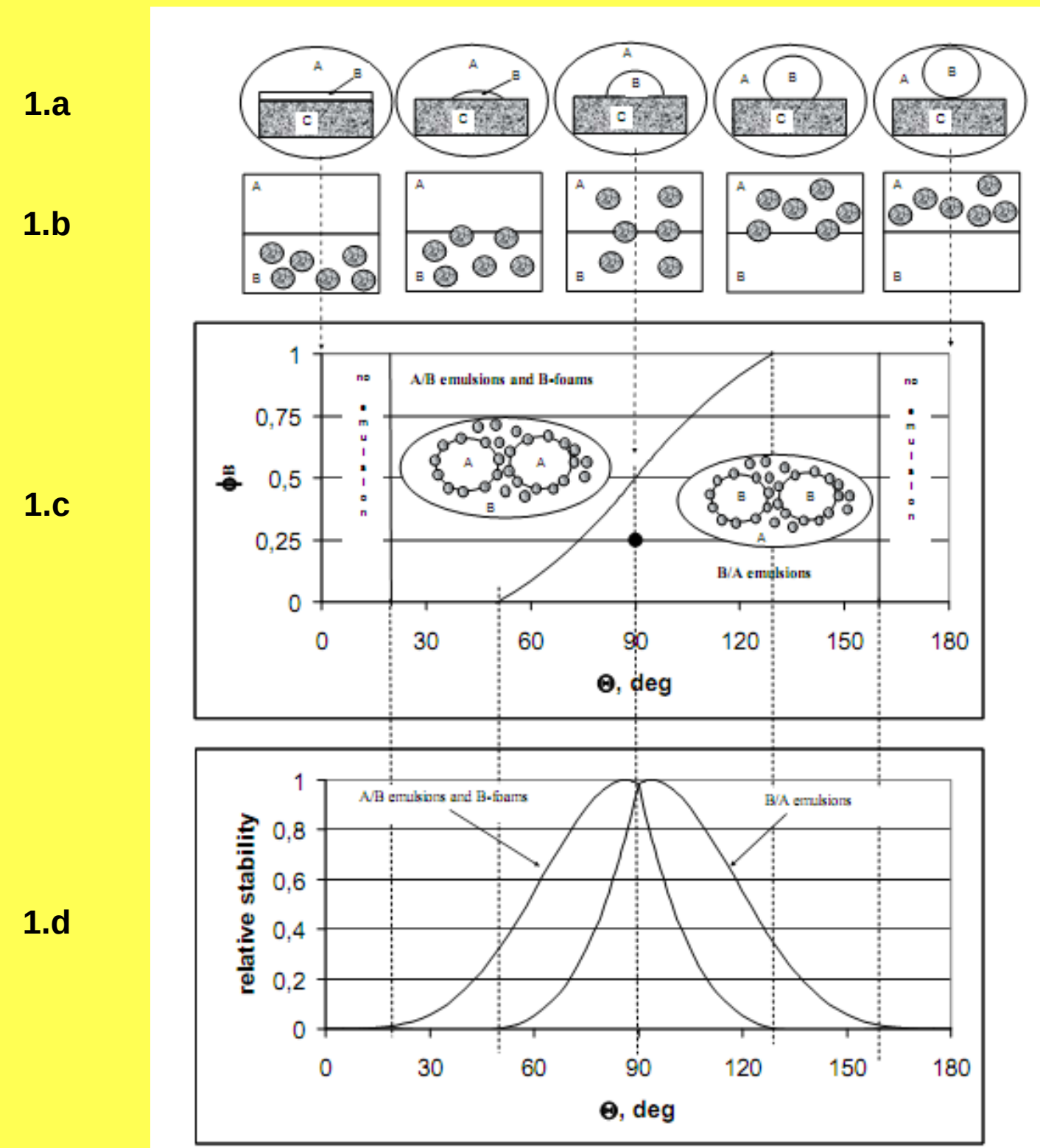


Fig. 1. Definition of the contact angle of liquid B on solid C in liquid A (1.a), preferred distribution of C between A and B (1.b), the emulsion stability diagram (1.c) and a relative stability of different types of emulsions (1.d) [5]

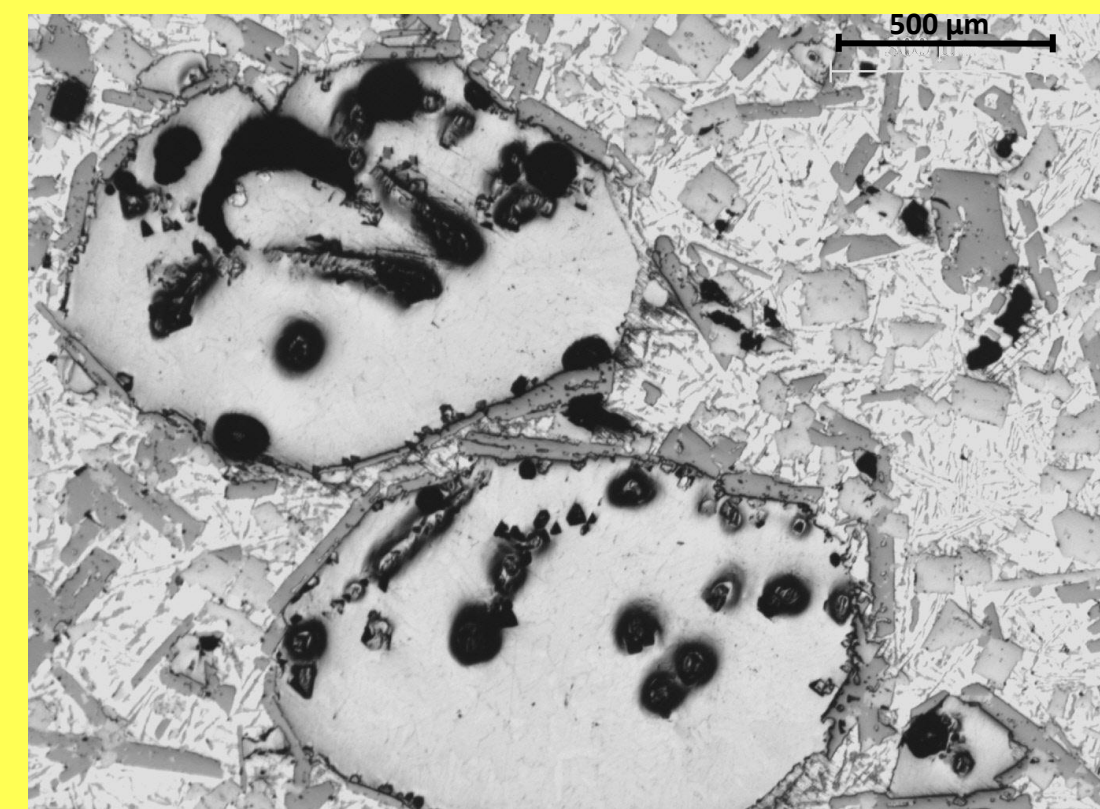


Fig. 2. Optical microscopic image of Bi droplets stabilized by in-situ formed primary Si crystals (matrix: eutectic Al-Si)

## Al-Si binary phase diagram with „in-situ” thermal program

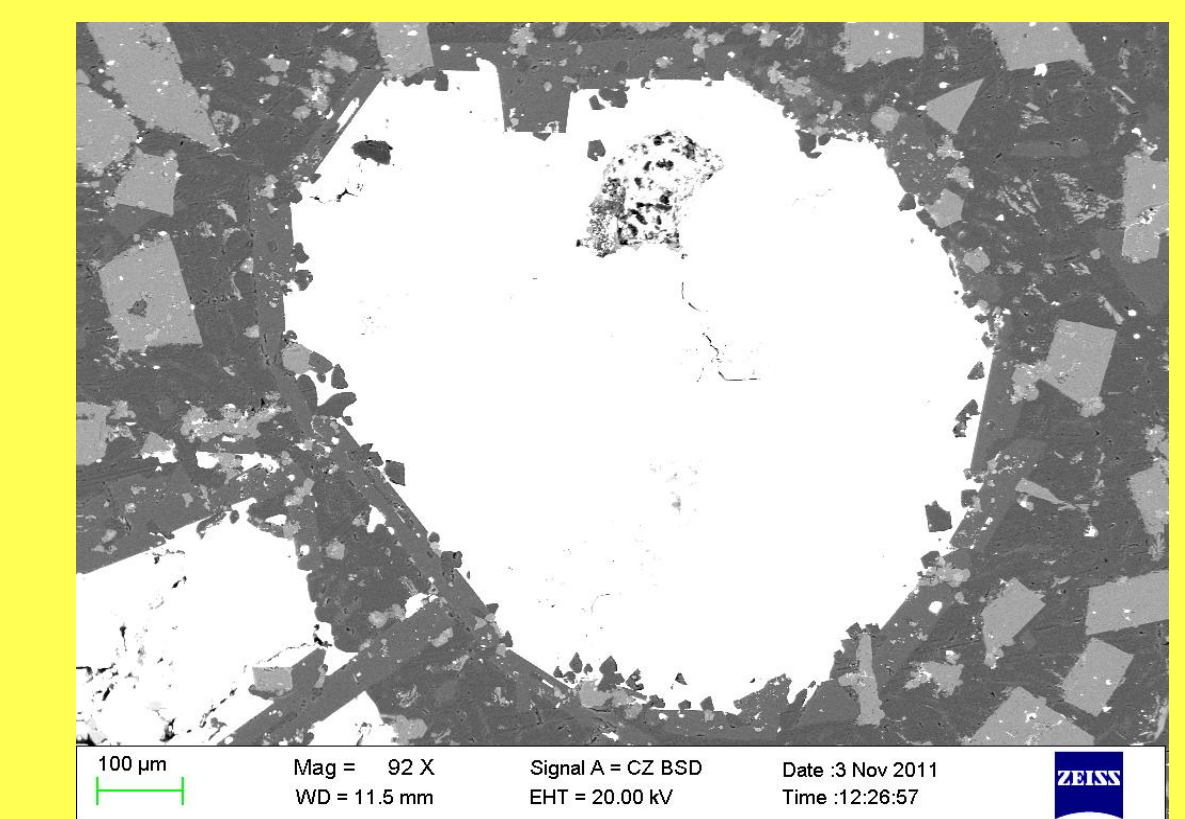
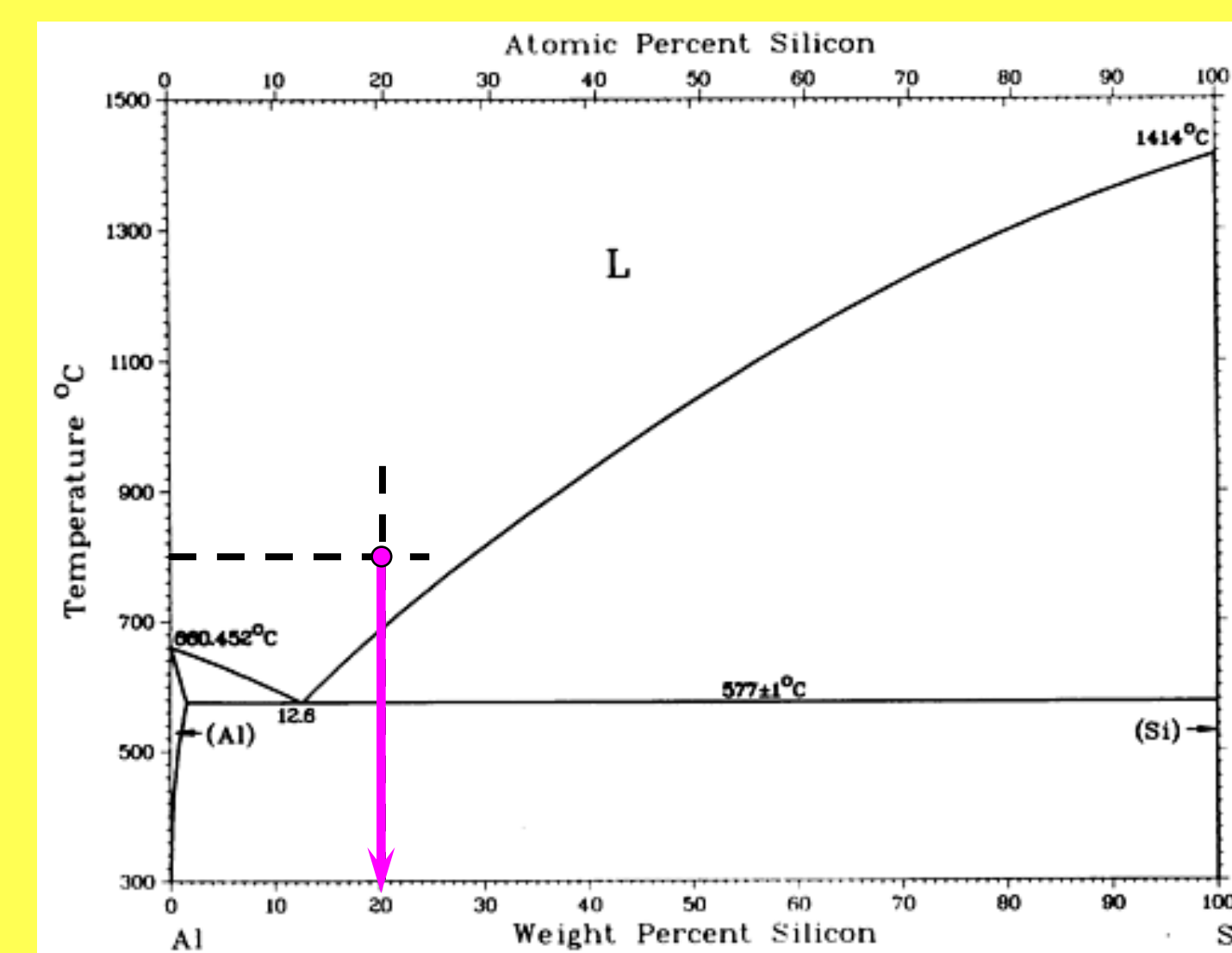
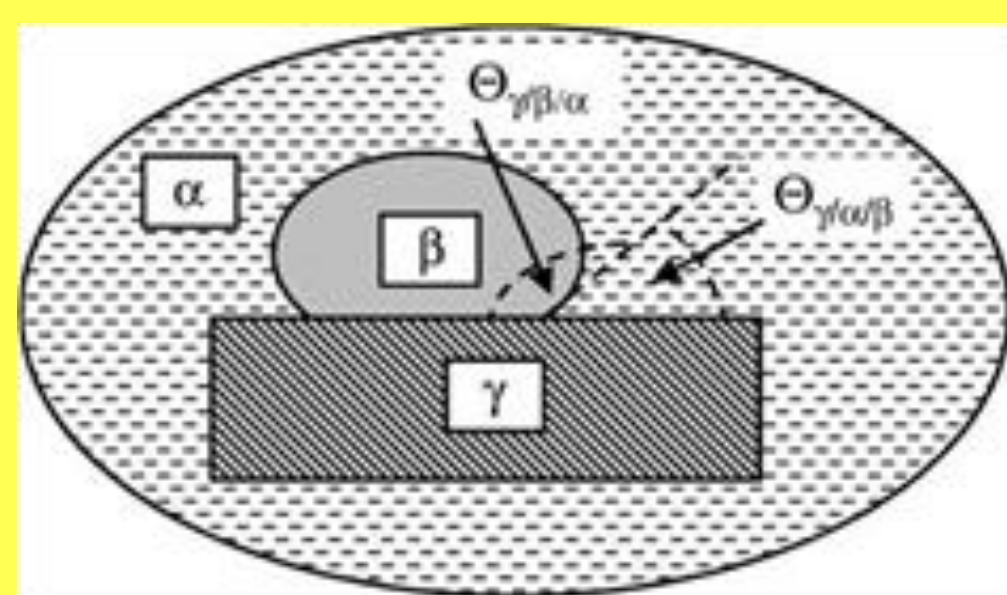


Fig. 3. SEM image of Bi droplet in Al rich matrix stabilized by in-situ formed primary Si crystals

## Measurement of contact angles

### The sessile drop method



$$\cos \theta_{\gamma/\beta/\alpha} = \frac{\sigma_{\gamma/\alpha} - \sigma_{\gamma/\beta}}{\sigma_{\beta/\alpha}}$$

Fig. 4. Definition of  $\theta_{\gamma/\beta/\alpha}$  (contact angle of  $\beta$  liquid phase on solid  $\gamma$  phase in  $\alpha$  medium) [6]

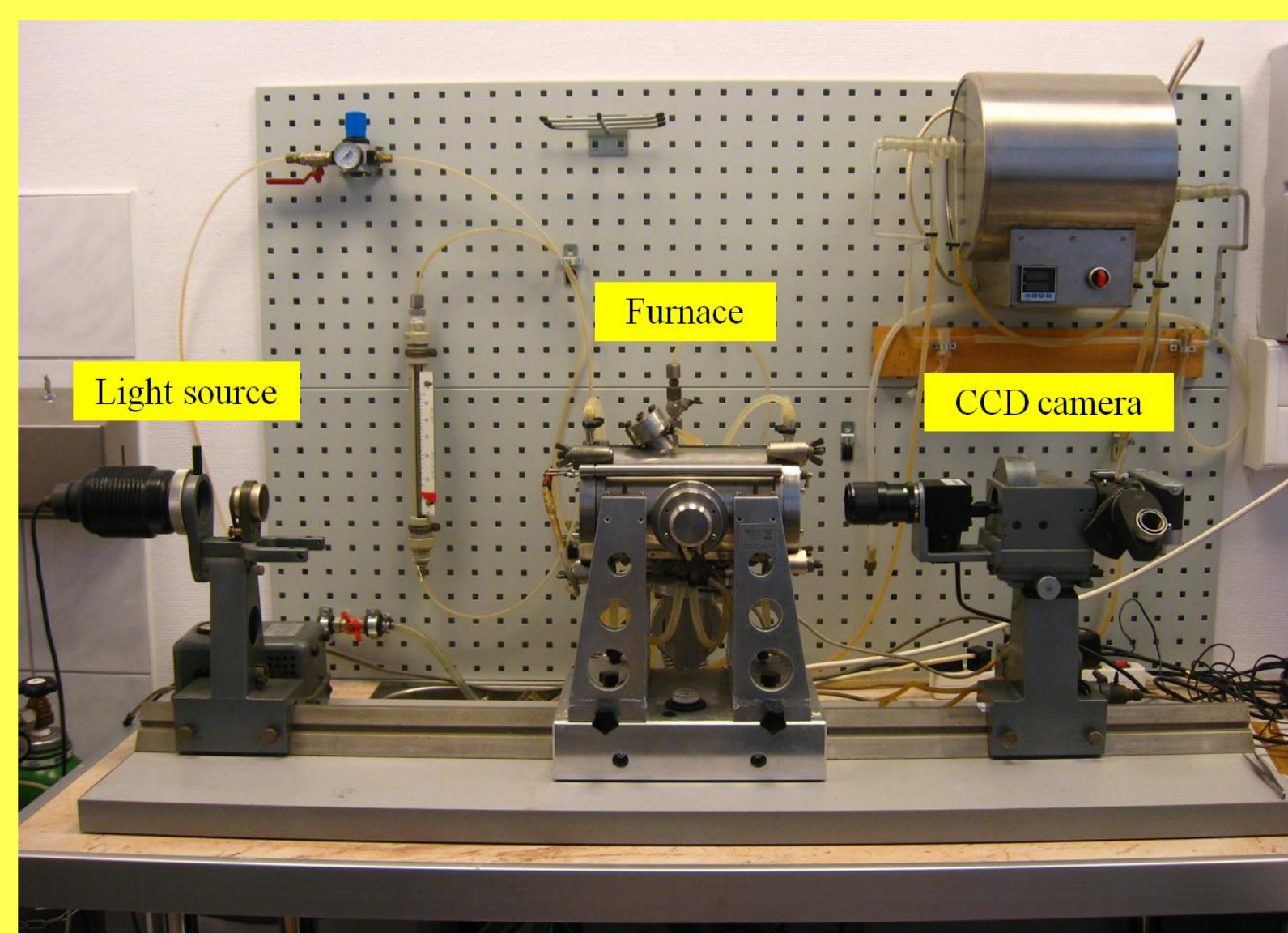


Fig. 5. Equipment of sessile drop method

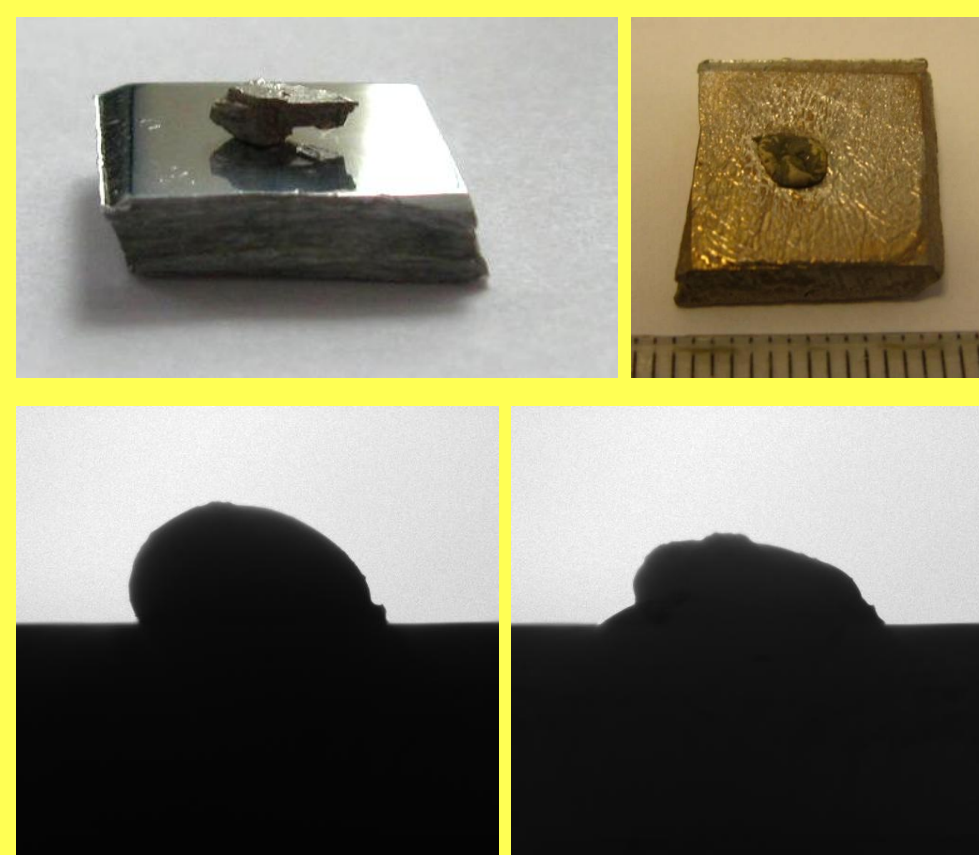
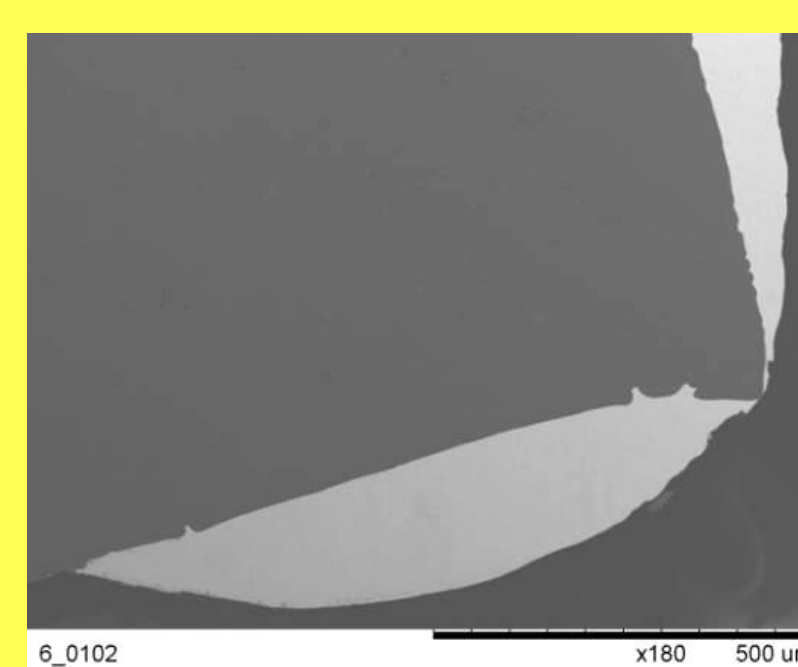
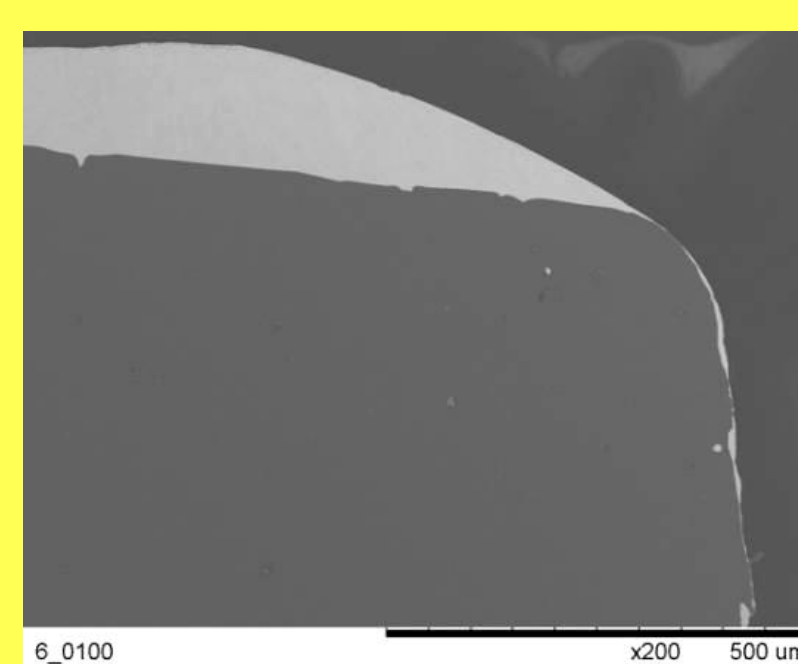
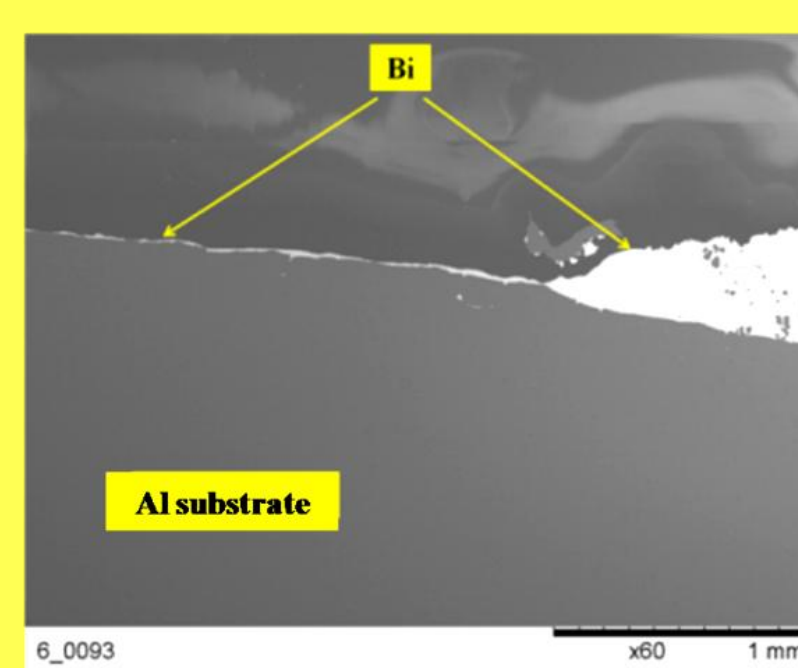


Fig. 6. Initial and final state of the sample and the silhouettes of the droplet

Table 1. Results of contact angle measurements in different systems ( $T = 750^\circ\text{C}$ )

| $\gamma$                | $\beta$ | $\alpha$ | $\theta$ |
|-------------------------|---------|----------|----------|
| Si                      | Bi      | Ar       | 131°     |
| $\text{Al}_2\text{O}_3$ |         |          | 159°     |
| Al-20wt%Si              |         |          | 107°     |
| Al                      |         |          | 0°       |

Fig. 7. SEM images of the aluminium plate covered by bismuth after the wetting test



### The image analysis of frozen samples

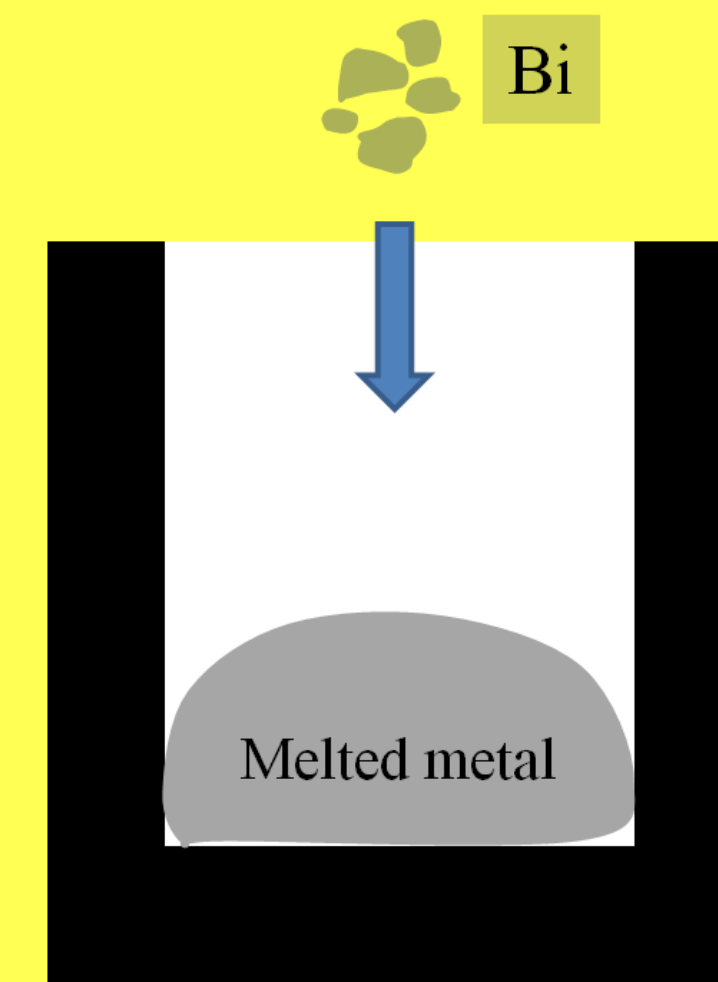


Fig. 8. Schematic of the experimental conditions ( $T=750^\circ\text{C}$ ; weak stirring) and the photos of the raw materials (Al-20wt%Si alloy, Bi) and the graphite crucible

### Selected sample area for in-situ contact angle analysis

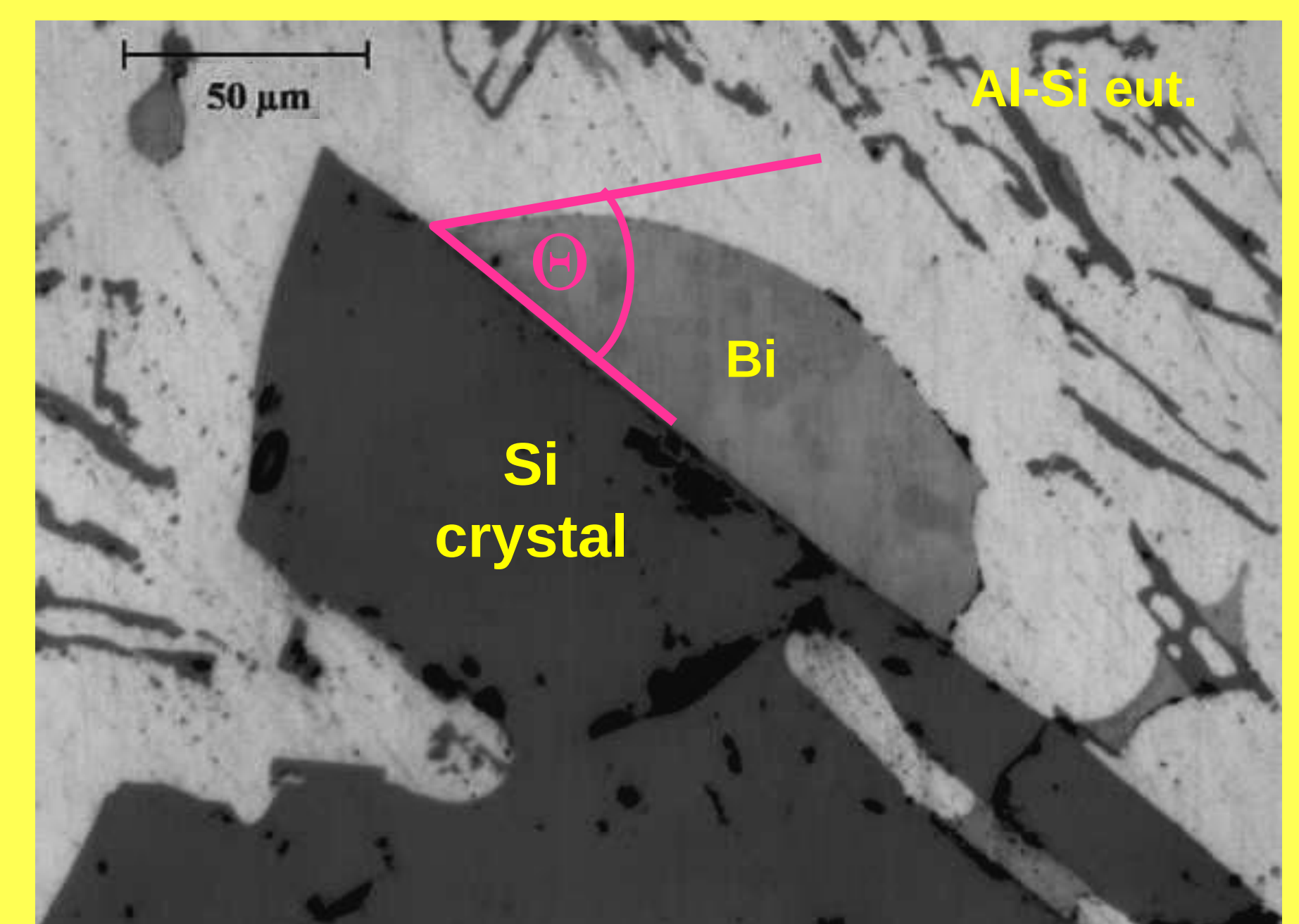


Fig. 9. Measuring of contact angle of in-situ formed Bi droplets on solid Si crystal in solid aluminium

$$\theta = 46^\circ \pm 5^\circ$$

### References:

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