High speed 4-Megapixel White-Light-Interferometry

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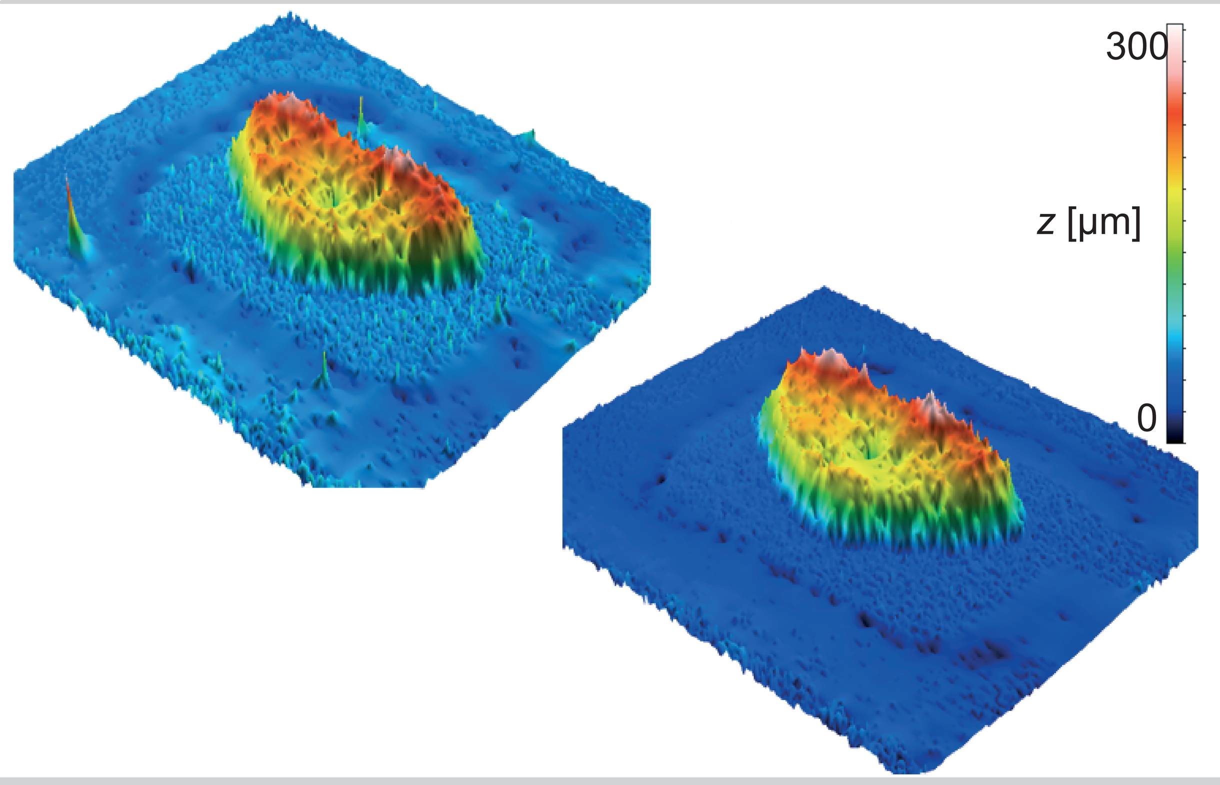

Fig. 1 *WLI measurements of solder bump. Right: common WLI, v=20µm/s. Left: novel method with v=500µm/s (40x undersampling). Measurements are performed with identical technology*

Industrial 3D-metrology demands for **accuracy, space-bandwidth (SBP) and speed**. Many applications require an accuracy in the regime of 1µm, which can easily be achieved by White-Light-Interferometers (WLI) [1]. However, WLI (and other accurate methods) are slow, specifically for **large field and high lateral resolution.** Typical measurement cycles in production lines are faster than **1 second**.

We demonstrate how to overcome this problem exploiting the physical and information theoretical margins, and by latest camera technology. We make WLI more **data-efficicient**: so a much smaller **number of raw images** is sufficent. We achieve 4 Mpix images with a depth scan speed *v*=0.5mm/sec.

Physics and information theory

The Michelson interferometer is equipped with a **broadband light source**. By scanning the object along the z-axis, we obtain an interference signal (**correlogram**) in each pixel of the camera detector.

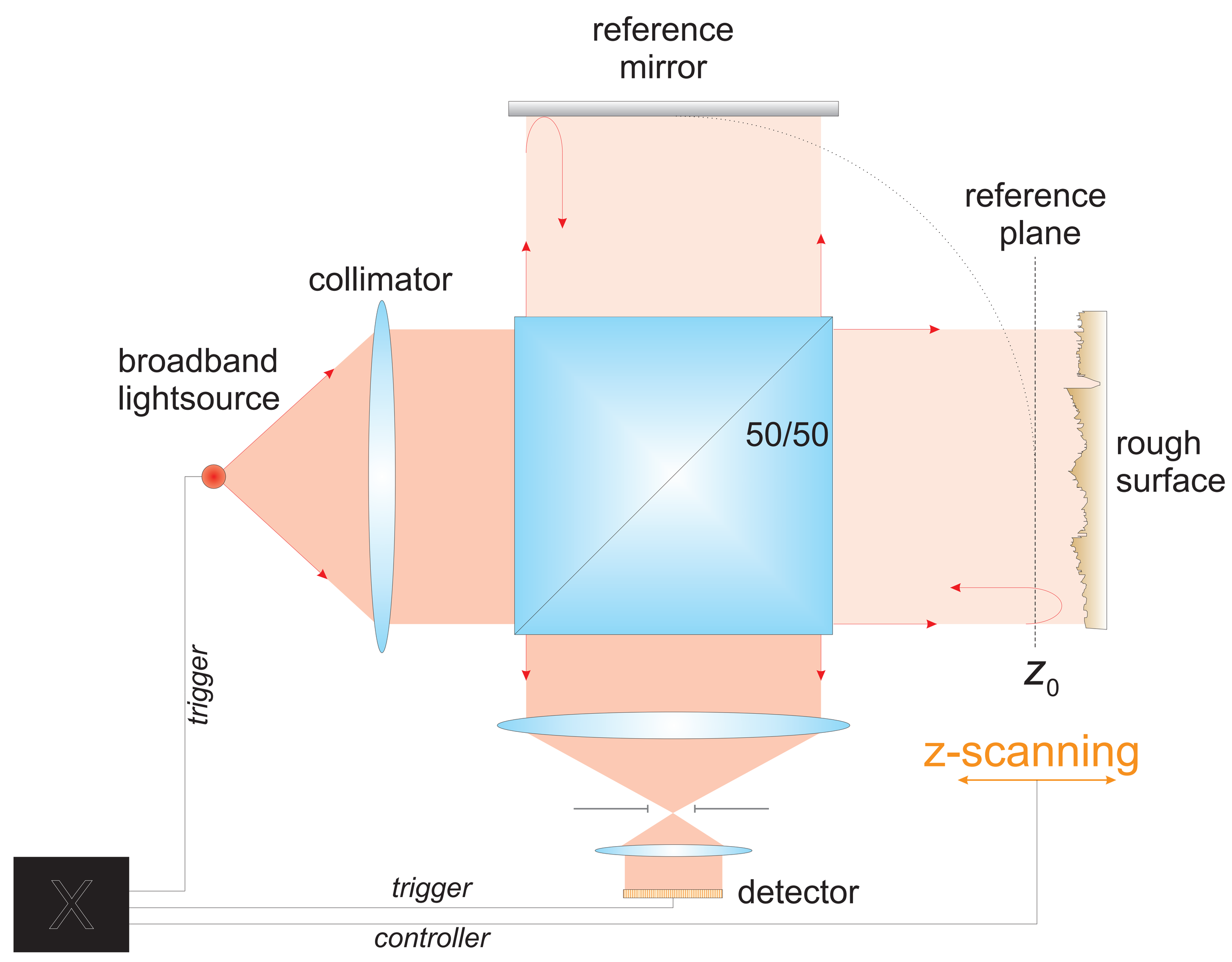

Fig. 2 *Measurement principle of WLI with a rough surface.*

The correlogram will be **highly undersampled** to achieve a high scanning speed *v*, as illustrated in Fig. 3. The high scanning speed requires synchronized strobe illumination with extremely high power.

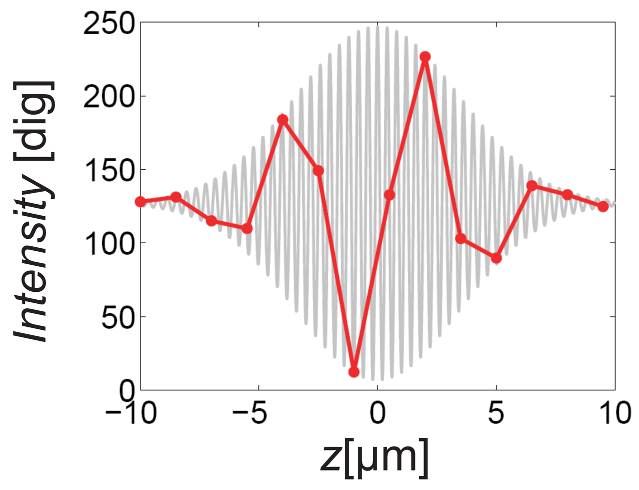

Fig. 3 *Comparison of a properly sampled correlogram (grey, 0.12µm stepsize) and undersampled correlogram (red, 2µm stepsize) measured for every pixel of the detector. The position of the maximum of the envelope corresponds to the height position of the measured surface.*

Technology

Meanwhile, **new 4 Megapixel cameras** are available with a continuous frame rate greater than **100 frames** per second. With **conventional sampling**, this would allow a measurement speed of **"only" 20µm/sec**. We achieve a measurement speed of more than **500µm/sec** by a novel sampling scheme and novel evaluation. This is possible because we neglect the information about the phase in the correlogram and just use the **maximum** of the correlogram.

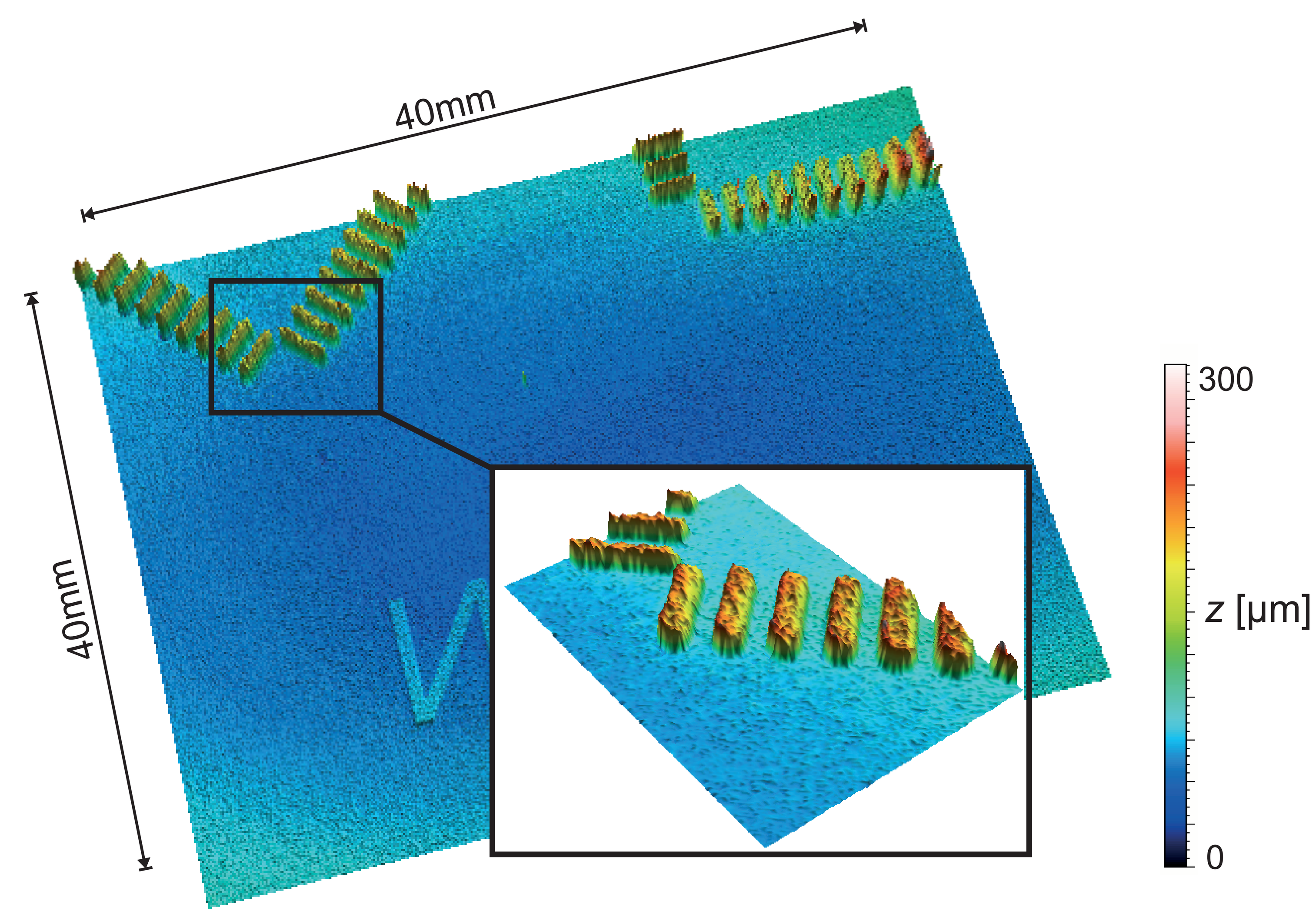

Fig. *4 Results of the measurement of an electronic board. A volume of 40x40x0.5mm was measured within one second.*

The sensor is **available** with the following specifications [3]:

- field of view: 40mm x 40mm
- lateral resolution: 20µm/pixel
- measurement uncertainty: ~1µm

[1] T. Dresel, G. Häusler, H. Venzke; „Three-dimensional sensing of rough surfaces by coherence radar", Appl.Opt., Vol. 31, No. 7, 919-925, (1992)
[2] P. deGroot, L. Deck, "Three-Dimensional imaging by sub-Nyquist sampling of white-light interferograms", Opt. Letters. Vol. 18, No. 17, (1993)
[3] 3D-Shape GmbH; http://www.3d-shape.com; [online]

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