

Coherent Fourier Scatterometry for defect detection on SiC samples

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Abstract. Coherent Fourier Scatterometry (CFS) is a scatterometry technique that has been applied for grating and nanoparticle detection. Here, it has been challenged to verify the detectability of the so-called killer defects on SiC samples for power electronic applications. It has been shown that CFS is able to precisely recognize these defects regardless of their shape or size. CFS could be considered as a possible alternative for this purpose.

1 Introduction

Scatterometry is a well-known and successful metrology technique in the semiconductor industry, and it has been mainly for the optical characterization of periodic samples [1, 2]. It is non-imaging method that is not limited by diffraction and also can be fast and non-destructive.

Coherent Fourier Scatterometry (CFS) is one of those techniques that have been developed based on scatterometry in which a coherent light beam is focussed on the sample and the Fourier plane of the objective lens is imaged on a CCD camera. [3]

CFS has been applied for grating characterization [4] and for detection of isolated spherical nanoparticles [5,6]. The implementation of the latter is similar to the one used for grating reconstruction except that the CCD camera is replaced by a split detector. Here, we adapt the CFS particle detection scheme to detect isolated defects of various shapes. High quality large area samples with low concentration of typical defects known for SiC technology are provided. The defects have roughly been located with a polarization microscope with magnification of 20x, NA=0.4, in cross-polarization mode. So far different methods have been used to analyse and detect these defects [7]. The main goal of this work is to verify whether CFS is able to detect, locate and classify these isolated defects.

2 Experimental Setup

In a conventional CFS setup, as shown in Figure 1, a linearly polarised He-Ne laser with a wavelength of $\lambda=632$ nm is coupled into a single-mode fibre and collimated by an off-axis parabolic mirror before it passes through the beam splitter (BS1) and focused on the desired sample by a high numerical aperture objective (NA=0.9). The sample is mounted on a 2D piezo-electric stage whose position can be controlled with sub-nm

precision (P-629.2CD by Physik Instrumente). During the experiment, the sample is moved in the lateral direction (x-y) in raster scan mode (parallel lines along the x axis). The z-position can also be finely tuned to find the best focus position on the sample. The reflected and scattered field is captured by the same objective and directed back to BS1. Then a telescopic arrangement formed by L1, L2, L3, and (BS2) is used to image the back focal plane of the lens into the camera aperture and the split detector (ODD3W2 BiCell Silicon Photodiode). The camera is only used here for localizing features on the sample. The split detector is aligned with both sides perpendicular to the direction of the scan of the stage (x axis). Both sides of the split detector are integrated and subtracted from each other generating a photocurrent I. that is dependent on the x-y position of the stage.

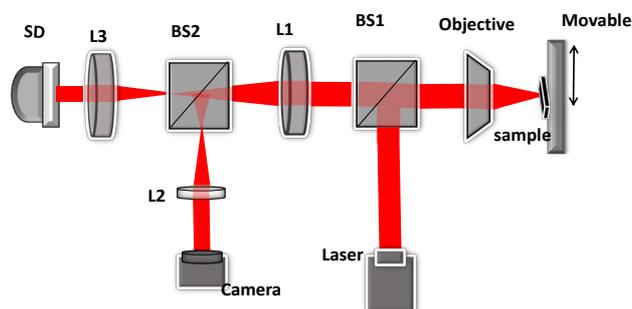


Fig. 1. The schematic of the CFS setup. The sample is placed on the stage with a piezo-electric XYZ translator, BS1 and BS2: 50-50 non-polarizing beam splitters, L1, L2, and L3: positive lenses; Camera: CCD camera used for localizing features on the sample; SD: split detector (bi-cell silicon photodiode). A He-Ne laser is used. The split detector is aligned perpendicular to the scan direction of one line of the raster scan (x axis).

2.1. Experimental results

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Samples containing a few types of special defects of interest provided by AIXTRON (ref. WF0053-40-5) have been analysed. The defects are called carrots and triangles. Two examples of the results of the detection of defects are shown in Figure 2. The raster scan takes place line by line. This is a method of construction of an image through the use of the signal on the split detector that is recorded in some fixed time intervals throughout each line scan (X axis). Then, the scan table is displaced in the y-axis by a Δy step. The values of Δy can be adapted. The smaller Δy is, more details can be obtained from the defect, but of course, it needs more lines and consequently, it takes a longer time to cover the same area than if it is scanned with a bigger Δy . Here we define the total scan $T = t_x \times N$ lines, where t_x is the scan time per line and N is the number of lines. In the present system, the optimum value for t_x is 150 ms, and it is presently limited by the response of the piezo table. In Figure 2 we show the results of the scattered maps of two types of defects, showing that one can clearly distinguish these two types of defects. Scatterometry is not an imaging technique and in the scan maps one sees the changes in the scattered patterns at the borders of the object, and in this way, the defect can be recognised. The scan time can be considerably reduced if bigger scan steps are taken at the cost of loss of resolution in recognizing a particular shape.

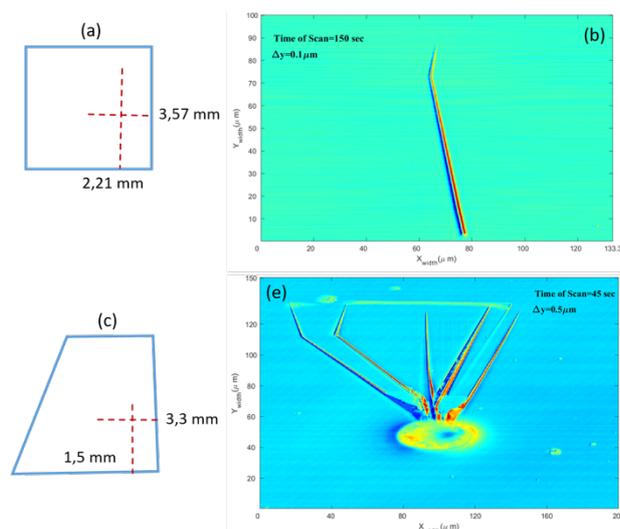


Fig. 2. (a) and (c) the rough location of the defects on SiC samples provided by AIXTRON. (b) and (e) represents the high-resolution scans of the defects, carrot and triangle, respectively. The scanned area and total time of scan T are indicated in each scan map.

3 Conclusion

We have shown how CFS can be applied for detection of non-symmetrical defects so-called killer defects in power electronics applications. The samples with such defects have been provided by AIXTRON together with a rough information about their locations and shapes. It has been shown that regardless the size or shape of the defects, they

are all recognizable using our technique. CFS has the advantages of being a compact setup that needs very low power laser ($60 \mu\text{W}$ in this case) and can be installed in line. However, in this stage, it is relatively slow compared to other known techniques especially when it comes to inspection of large areas. The speed could indeed be improved using different raster scan schemes and also by implementing parallel multiple laser spots.

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