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Fraunhofer-Institut für Zerstörungsfreie Prüfverfahren IZFP

Campus E3 1
66123 Saarbrücken

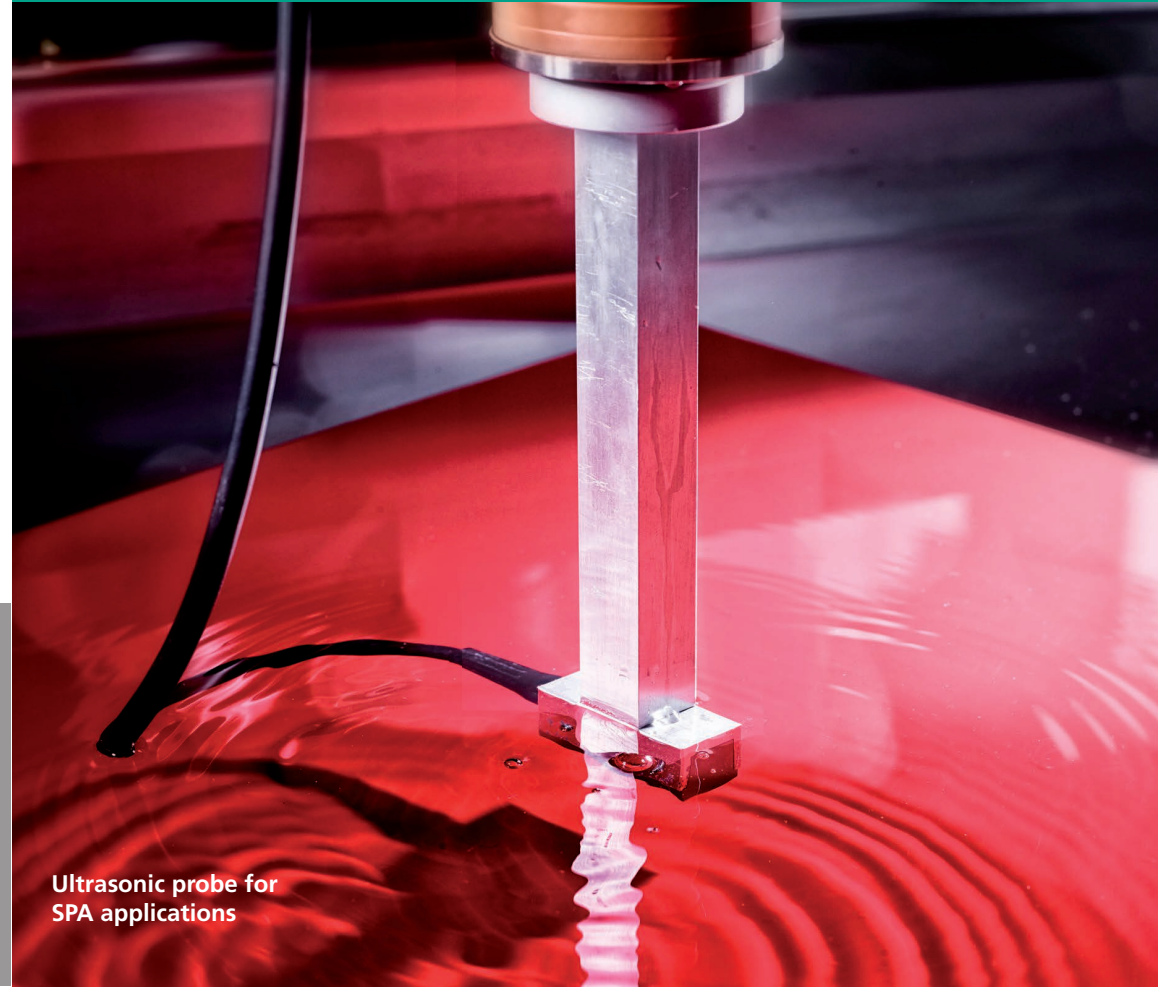
+49 681 9302 0

info@izfp.fraunhofer.de
www.izfp.fraunhofer.de

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**NONDESTRUCTIVE INSPECTION AND
CHARACTERIZATION OF MATERIALS AND
COMPONENTS BY SAMPLING PHASED ARRAY**



**Ultrasonic probe for
SPA applications**

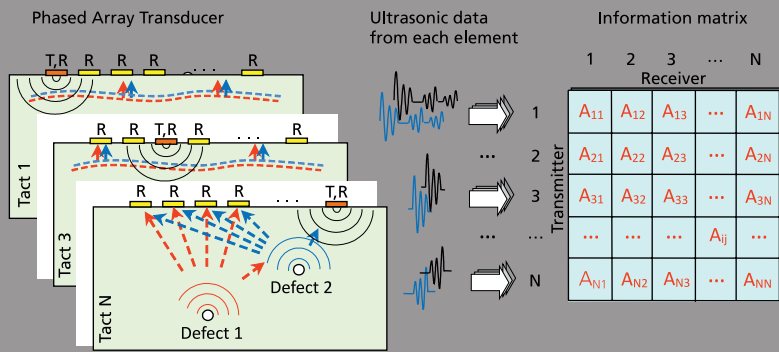


Fig. 1: SPA technique, data acquisition: all possible $N \times N$ ultrasonic signals from N -elements PA-transducer are processed in real time to produce 2D and 3D tomographic images for the qualitative and quantitative characterization of the test objects

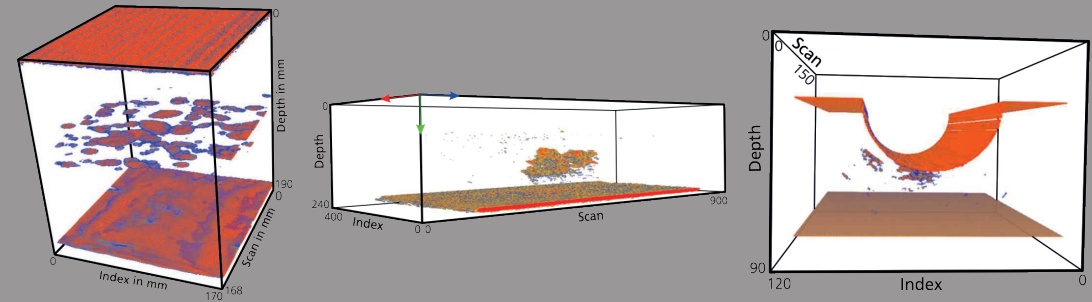


Fig. 2: Examples of SPA applications: 3D visualization of volume defects, also in objects with complex shapes

Situation

Guaranteeing a long term failure-free performance as well as the safety of manufactured components are two essential preconditions in industry, especially in power plants and transport (aerospace, railway, automotive). Among the different available nondestructive testing (NDT) methods to fulfill this task, the ultrasonic technique (UT) is a well-established and accepted method that allows the quality control of components.

Conventional ultrasonic techniques have limitations in flexibility (every application needs specific test setup and transducers), accuracy and performance. Phased array (PA) as an enhanced UT technique enables the hardware based sound field control (beam steering and focusing) which permits new imaging tools such as sector scan, easier interpretation of the test results and increased test speed ability. However, PA is not able to overcome the limitations of conventional ultrasonic testing, i. e. only qualitative and relative characterization of defects are possible and complex material properties (e. g. inhomogeneity, anisotropy etc.) have a strong influence on the results.

Solution: Sampling Phased Array (SPA)

For SPA data acquisition a standard phased array transducer can be used, whose elements are sequentially initiated (one by one) and all the elements receive the ultrasonic signals coming from material (fig. 1). A small aperture of each element is sending acoustical waves in all directions simultaneously. As a result of the SPA data acquisition the signals of all possible combinations "transmitter-receiver" have ultrasonic information from all the points within the scanned aperture. This complete information is used for the fast GPU-based reconstruction of tomographic 2D/3D images (fig. 2) where the ultrasound is synthetically focused in each point of inspected volume.

Advantages

- An innovative ultrasonic technique with superior performance in solving complex inspection tasks – from defect detection and sizing to estimation of material properties and correction of anisotropy/inhomogeneity in different materials and industrial objects.

- Improved imaging ability which allows a quantitative characterization of material properties and material defects such as cracks, porosity, inclusions etc.
- 2D and 3D tomographic representation of inner structures enables an improved ultrasonic testing. The SPA inspection systems can be used for real time inspection as well for offline analysis.
- Higher failure detection ability with an improved defect resolution; allows the quantitative characterization of a structure (defects and/or material properties) in real time
- Using the enhanced information content for additional data processing such as anisotropy and inhomogeneity correction (in austenitic welds or fiber-reinforced composite materials, fig. 3/4) and noise elimination based on the statistical distribution of the phase values of received signals (in coarse-grain materials or in the objects with complex geometries such as railway solid axle, fig. 5).

The SPA technique is patented by Fraunhofer IZFP (DE 10 2004 059 856 B4 2006.09.14)

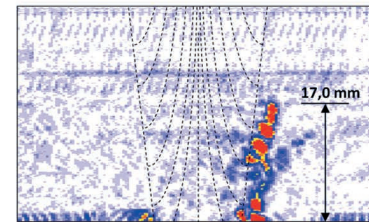


Fig. 3

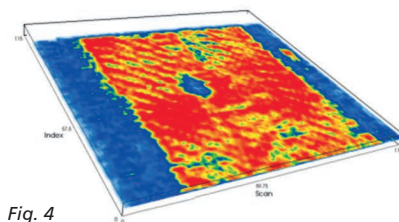


Fig. 4

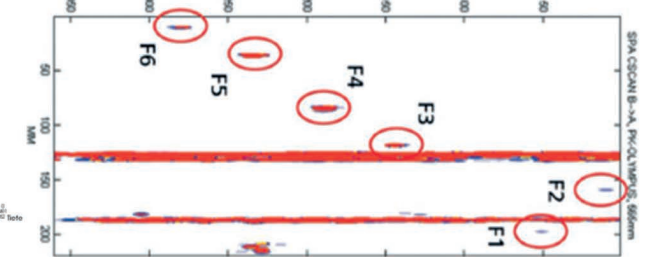
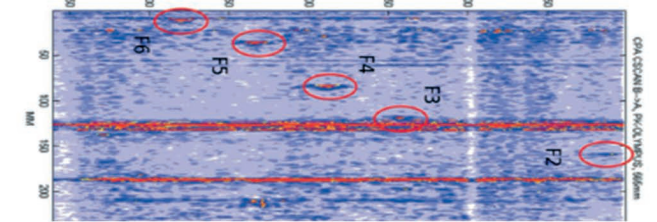


Fig. 5

Fig. 3: Real crack in austenitic weld, SPA with anisotropy and inhomogeneity correction, B-view
 Fig. 4: Imaging based characterization of the materials properties in CFK plate, 3D view
 Fig. 5: UT of railway solid axle: PA (top) vs. SPA with noise elimination, C-view