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Investigations on strain behaviour of polymer substrates during a separation process

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Abstract

Magnetic field sensors are used for contact free position detection of machine components for example. Fabricating these sensors on a flexible substrate enables the user to attach the sensor on various surfaces and different installation situations [1].
Within the Collaborated Research Center 653 a modular anisotropic magnetic field sensor on a flexible polymer substrate has been developed. In a next step the sensor should be transferred into an industrial application [2].

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Keywords: deformation of flexible substrates; modular magnetic field sensor; Collaborative Research Center 653

1. Introduction and state of the art

The collaborative research Center 653 broaches the issue of “gentelligent components in their life cycle.” Gentelligent is a word made up of the terms genetic and intelligent and describes a method of how components can inherit their product- and operator data to the next generation of components [3]. Thereby it is necessary to do research of methods that enable to bring in, collect, combine, read out and use information during the life cycle of a device [4]. The experiments made within this subproject deal with an anisotropic magnetic field sensor on a flexible and thin substrate and belong to the category of components which collect information.

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Thin film magnetoresistive sensors are frequently used as for example read heads, mechanical transducers, and magnetic field sensors [5]. The anisotropic magnetic field sensor (AMR sensor) is one of the most important sensors within the group of magnetoresistive sensors. Other effects that can be used in the field of sensor technology to detect an extern magnetic field are the giant magnetoresistance (GMR) effect, the colossal magnetoresistance (CMR) effect and the tunnel magnetoresistance (TMR) effect.

In this subproject the ultimate aim is to integrate the magnetic field sensor into an ABS System in order to detect the rotation speed. Setting up the AMR sensor on a thin and flexible polymer substrate involves as well advantages as challenges. On the one hand the flexible substrate enables the user to attach the sensors to various surfaces and installation situations. Further the flexible substrate can be fabricated much thinner as a solid substrate; only several micrometers thick.

Thin substrates have become essential for the research field of flexible electronics. Several flexible substrates are already used in the field of flexible electronics that vary in their Modulus, their glass transition temperature and their photolithographic process suitability [6]. They are for example applied in flexible conductor boards and silicon chips which are integrated into small portable electronic devices like mobile phones, laptops or clocks. Recently Biomedical engineering has become an application range as well where flexible polymer foils serve as a medium for micro electro mechanic systems. The medical area benefits from the flexible substrates as it can adapt to any surface [4].

Processing a sensor on a flexible polymer substrate brings three major challenges with it: The fabrication of the microsystem on a polymer substrate itself, releasing the polymer based microsystem from its temporary medium and the electrical as well as mechanical contacting of the microsystem.

The investigations described in this paper focuses on the releasing process of the microsystem from its medium.

The standard way of individualizing microsystems, that have been processed on a solid substrate like silicon or ceramic is to separate them by abrasive cutting where diamond coated saw blades cut through the material. If the microsystem is build up on a flexible polymer a simpler and less energy intensive cutting process can be chosen in order to cut through the polymer. The disadvantage when building up a microsystem directly on a flexible and thin substrate is its difficult handling due to the low stiffness of the polymer complicating thin film processes like photolithography, electroplating or vacuum deposition. The here used innovative way of fabricating a sensor is to deposit the polymer on a solid silicon substrate before building up the microsystem on it. When the system is processed completely the silicon is only partly removed. The remaining silicon grid is still functioning as a supporting medium and simultaneously exposing the microsystem on the polymer substrate that can be removed without having to saw through the solid silicon.

The here described concept provides to separate the sensors from their assemblage with a stamping tool, that has a planar tip of the size of a single sensor. This separation process will cause a strain of the flexible substrate and the sensor layers respectively. It is necessary to analyze this releasing process in order to identify the occurring strains and decide if the strain is causing any damage of the microsystem or the polymer substrate respectively.

2. Sensor Design

The anisotropic magnetic field sensor is fabricated on a polymer resist which is spin coated in a liquid form on a 4 inch silicon or silicon dioxide wafer and structured by photolithography in order to create spaces, in which contact pads can be grown galvanic. Afterwards the polymer layer is cured in a hard bake process at 350°C for one hour. The substrate becomes thereby stabile towards temperatures of up to 350°C as well. The sensor layers are deposited onto the polymer membrane consisting of the meander containing the functional layer (permalloy), the contact pads and the feed lines which are made out of copper. In a next step a second polymer film is spin coated on top and cured as well at the same temperature. The silicon substrate is partly removed in a deep reactive ion etching process. This process is a key element in the fabrication of these sensors, as it creates very straight flanks and therefore realizes a high aspect ratio.

Accordingly a silicon grid with web thicknesses of only 200 µm remains exposing the membrane's backside as well as the contact pads [2]. As the silicon is removed, the polymer layer undertakes the task of serving as a substrate and as an isolating layer.