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Wet release of multipolymeric structures with a nanoscale release layer

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Abstract

A promising wet release process using OmniCoat™ [1] has been developed for the release of the multilayer microsensor device that is being used for biomedical applications. OmniCoat™ has high thermal stability (Tg ∼190 °C) which makes it compatible with high temperature processes. A multilayer fabrication approach and OmniCoat™ release layer was successfully integrated for a microsensor device to be released from the substrate. Thickness and release rate of OmniCoat™ release layer was investigated. The effects of OmniCoat™ development on the optical properties of SU-8 were analyzed. Highly aligned structures and good adhesion between metals and cured polymer layers have been achieved. OmniCoat™ as a release layer has great potential in several other MEMS applications where SU-8 is used as a structural material.

Keywords: OmniCoat™; Release layer; Microsensor; MEMS fabrication; SU-8; Polymeric

1. Introduction

SU-8 is an ultraviolet sensitive negative tone photoresist which is being used in various MEMS applications such as microfluidic systems, lab-on-a-chip, optical microsystems, etc. [2]. It is one of the most suitable materials which is used as a structural layer for different MEMS and bio-MEMS devices. SU-8 is specially used in the biomedical field since it is a biocompatible polymer with thermal and chemical stability [3]. Its very high optical transparency for exposure light above 360 nm makes it ideally suited for imaging near-vertical sidewalls in very thick layers [4]. SU-8 processing uses standard contact lithography which is a low fabrication cost process. Furthermore, it has high aspect ratio, and excellent chemical and mechanical properties [5]. Thickness of SU-8 films can be controlled by its viscosity and spinning conditions achieving thickness from the range of 1–450 μm (Microchem).

A key step in the fabrication process of SU-8 devices is the release of the finalized microchips. This step brings a little difficulty, since cross-linked SU-8 is very hard to release/remove and may affect the integrity of the microstructures during this process. It could be a time-consuming step as well. Another difficulty is the difference of the coefficient of thermal expansion (CTE) between standard substrate materials and SU-8 [6]. SU-8 has a high CTE [7] so this difference causes relatively high stresses to the structures, making SU-8 films to crack.

Several methods and techniques are used to release SU-8 structures and reduce stress in them caused by the interface with the substrate. There are basically two techniques to release polymeric structures: dry and wet release. In the dry release technique, low free surface energy films such as self-assembled monolayers and spin coating of fluoropolymers (e.g. Teflon) are used to reduce the adhesion between the substrate and the microstructure. In wet release technique, a sacrificial layer material (e.g. polystyrene) is deposited over the substrate prior to polymer deposition. This sacrificial layer should be soluble with a specific solvent or etchant (e.g. toulene). This specific method is targeted for SU-8 structures with dimensions of square centimeters. Metals such as gold, chromium, copper and aluminum are also used as sacrificial layers to be wet etched [8]. However, depending on the sacrificial material used, it can take up to several hours to release microstructures of several mm^2 (∼160 nm/min for aluminum). Furthermore, wet release techniques can introduce contamination and may attack metallic or polymeric coatings on the SU-8 due to insufficient selectivity [9].

In this present work, wet release of polymeric structures with a nanoscale release layer was accomplished. Fully released multipolymeric chips were obtained using OmniCoat™ (from MicroChem) as a sacrificial layer. OmniCoat™ is from the line of the PMGI resists with proprietary solvent blends. Also, it is readily soluble in most standard alkaline photoresist developers

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and has highly controllable dissolution properties. In addition, OmniCoat™ has high thermal stability (Tg ∼190 °C) which makes it compatible with high temperature processes. It is optically transparent and has superior adhesion to many substrates materials such as Si, NiFe, GaAs, InP and many other III and V group materials. Tetramethylammonium hydroxide (TMAHT) 0.26N developers such as AZ 300 MIF can be use to develop OmniCoat™. A very thin nanometric layer of about 13 nm thickness is applied to the substrate prior to polymeric depositions. It is a simple, easy and fast release method. This release layer was experimented in the fabrication of a multipolymeric multilayer microfluidic system. This device will be used throughout this paper as an example of a SU-8 device that uses wet release process.

2. Experimental

2.1. Materials and instrumentation

The SU-8 and OmniCoat™ were obtained from MicroChem Corp. Positive photoresist S1813 was available through Shipley Company. The positive photoresist developer, AZ 300 MIF, was acquired from AZ Electronic Materials. Plain glass 4 in. × 4 in. × .06 in. wafers were obtained from Towne Technologies Inc. Four-inch silicon wafers were acquired from Customized Communications.

2.2. Microfabrication

The first step in the fabrication process was the deposition of an OmniCoat™ release layer on a glass substrate, which allowed the multi-layered SU-8 devices to be removed easily from the glass after fabrication. The thickness of the OmniCoat™ release layer was characterized with different rpm's. Table 1 and Fig. 1 contain the spin curves for OmniCoat™, showing very small thin films from around 17–12 nm range, from low to high rpm speeds, respectively.

The spin speed chosen was 3000 rpm, giving a film thickness of ∼13 nm.

After the spinning and baking of the release layer, a thin (10 μm) layer of SU-8 was formed by spin coating and acted as a base layer for the rest of the device and provided adhesion to the OmniCoat™ release layer. The second step involved the deposition and patterning of a thick (150 μm) SU-8 layer that provides the structural support for the device. Furthermore Chromium/gold metallization (200 Å chromium and 1300 Å gold) was sputtered deposited and patterned on top of the SU-8.

Table 1
Spin curves for OmniCoat™

Speed (rpm)	Thickness (nm)
1000	16.7022
1500	16.6887
2000	13.6023
2500	12.6762
3000	12.6444

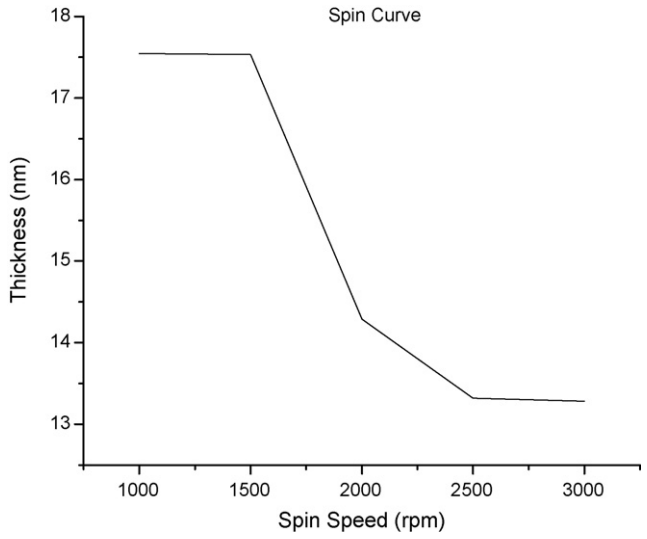

Fig. 1. Spin speed vs. thickness curves for OmniCoat™.

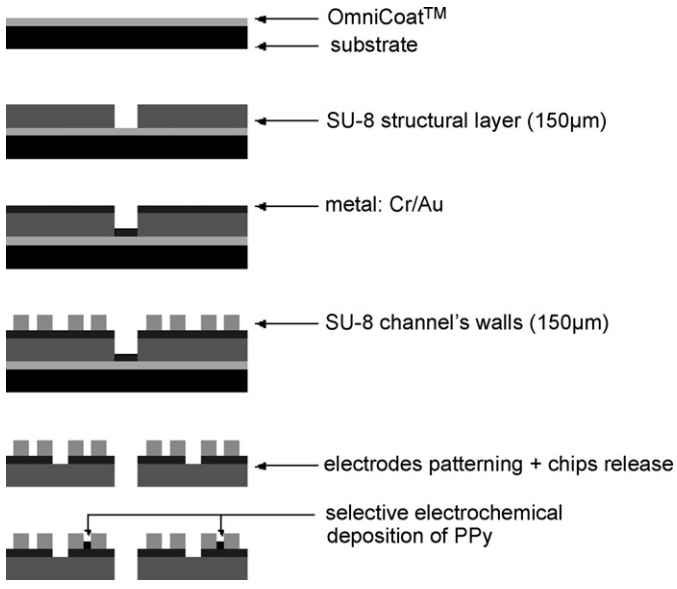

Fig. 2. Multipolymeric SU-8 based microsystem fabrication process flow (cross section).

The metals were patterned using positive photo-resist and wet chemical etching. A detailed fabrication process flow is shown above in Fig. 2.

3. Results

3.1. Multipolymeric microsystem release

A successful method of releasing polymeric structures was demonstrated by using OmniCoat™ as a sacrificial layer. Completely released multipolymeric microchips were obtained after 1 min of development in AZ 300 MIF positive photoresist developer. Fig. 3 shows digital images as well as SEM images of the successful released multipolymeric microchips.