

New Process for Fabrication of Microcomponents Using Metal Nanopowder

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ABSTRACT

A new process to manufacture small parts was developed using two kinds of polymer, SU-8 for a master mould and Polydimethylsiloxane (PDMS) for a soft mould, and the small parts produced via the new process were investigated in physical properties, such as density and shrinkage. PVB (polyvinyl Butyl) is proper use of binder to fabricate a microcomponent in the new process. Relatively clear shape of green component could be achieved by using the new process, but physical properties for the sintered ones were not enough to produce good microcomponents. In order to apply the new process to the fabrication of microcomponents, more advanced studies should be performed for enhancing the density of the sintered components by increasing compaction intensity of powders into a PDMS soft mould.

Keywords: microcomponent, soft mold, metal nanopowder

1 INTRODUCTION

Recently, many efforts are focused on the production of micro device with high performance. Micro device, such as micro electro mechanical system (MEMS), shows the largest amount of growth and the greatest potential for further increases. To produce the micro devices, a number of parts, much smaller than the devices in size, should be fabricated. But it is very difficult to produce the ultrafine parts composing the device due to a limit of mechanical skill for manufacturing a micro-mould. A photo-resist, such as SU-8, is applied to a fabrication of mould for microcomponents, however it is hard to demould a green component from a SU-8 mould and use the mould for several times. Since the PDMS soft mould is flexible, its use is recyclable and demoulding process of green compound can be simply conducted [1, 2]. In this study, we developed a new process to manufacture a PDMS soft mould for the microcomponents

2 EXPERIMENT

A PDMS mould was fabricated by pouring a mixture of PDMS and curing agent (Sylgard; dow corning) to a Petri dish with a master mould with a specific shape and drying it at 65 °C for about 4 hrs. Figure 1 shows the fabrication process of PDMS soft mould. 17-4 PH stainless steel

micro- or nano- powder was mixed with a binder and acetone. The mixed solution was fed into the PDMS soft mould, and green components with a specific shape were formed by drying it at 20 °C and sintered at 1250 °C.

To find proper kind of binder to the new process, green components with simple cylinder shape were formed with various kinds of binders, such as crystal bond, PEG, and PVB, and the shapes of the sintered were observed by an optical microscope. And green components with gear shapes were fabricated with a quantity of the optimum binder to the micro- or nano-powders, and their physical properties, such as density and shrinkage, were investigated.

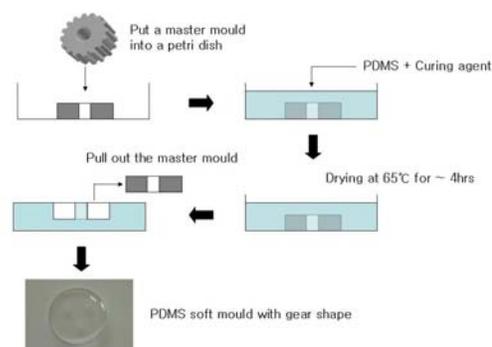


Figure 1 PDMS process for a specific shape soft mould

3 RESULTS AND DISCUSSION

3.1 PDMS Soft Mould

Figure 2 shows PDMS soft negative moulds replicated from a master mould. As described in the previous research results [3], the sizes and shapes for gear molded in the PDMS soft moulds are almost same as ones for the master moulds.

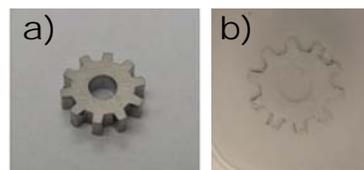


Figure 2 a) Master mould and b) PDMS negative mould

3.2 Binder

Figure 3 shows the green components fabricated with various kinds of binder. Relatively clear round shapes were found in the green components for the crystal bond and PBV, but some powder residues were found in the PDMS soft mould used for crystal bond. These indicate that the use of PVB is more reasonable than that of crystal bond in the new process.

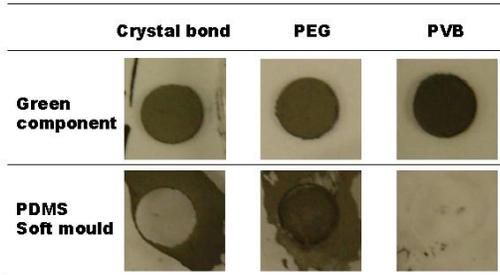


Figure 3 Green components and PDMS soft mould with a kind of binder

3.3 Microcomponents

Figure 4 shows the fabricated green components and their sintered ones with quantities of PVB added to 17-4PH stainless steel micro-powder and their densities and shrinkages. The green components with more than 20 wt.% of PVB have relatively good shape, but the sintered ones show the unsatisfied physical properties; low densities and high shrinkages. By considering shrinkage of the sintered compact, it is reasonable to add 20 wt.% of PVB to powders in the new process for fabrication of microcomponents. Figure 5 shows the green and sintered components fabricated by 17-4 PH nano-powders with 20wt. % of PVB. The physical properties for the components consisting of micro-powders were similar to that of nano-powders, but the sintered compact of nano-powders were higher than those of micron-powders in shrinkage. These are due to the low compaction density originated from no pressure applied to the process for manufacturing the green components.

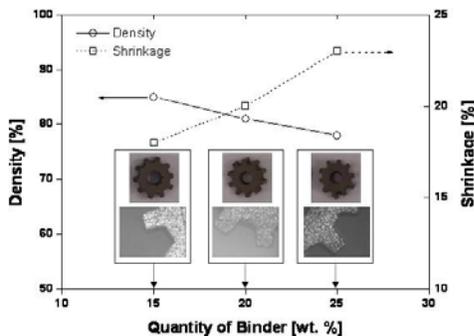
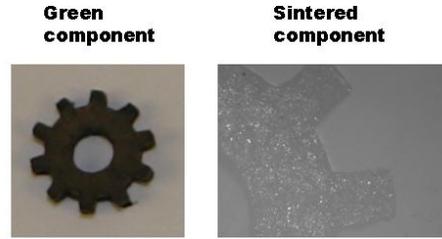


Figure 4 Green and sintered components consisting of micro-powders with additive quantity of binder and their physical properties

Accordingly, it could be known that 20wt.% of PVB is



Density: 80-82%, Shrinkage: 29.6%

Figure 5 Green and sintered components consisting of nano-powders and 20wt. % of PVB

proper use of binder to fabricate a microcomponent in the new process using a PDMS soft mould. Relatively clear shape of green component could be achieved by using the new process, but physical properties for the sintered ones were not enough to produce good microcomponents. In order to apply the new process to the fabrication of microcomponents, we are planning to perform a more advanced study enhancing the density of the sintered components by increasing compaction intensity of powders into a PDMS soft mould.

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