

# A HEAT RESISTANT LABEL MATERIAL AND ITS APPLICATION IN HIGH TEMPERATURE PROCESSING



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## A Heat Resistant Label Material and Its Application in High Temperature Processing

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**Abstract** A high temperature, pre-ceramic label material was prepared with a three layer format: ink-receptive, base, and adhesive layers. The labels survived through a high temperature process (up to 900°C) on both ceramic and steel surfaces. By using a fully decomposable ink-receptive layer and a base layer cast from a blend of inorganic powders and polymeric binders, this work demonstrated a low cost method to identify an object that need to go through a high temperature process and will facilitate a process control in a harsh environment.

**Key words** identification, label, heat, cost, process control.

### Introduction

There is a desire to continuously improve the control of process, inventory, and quality with implementation of an in-process barcode system. However, how a barcode label survives in a high temperature condition, such as 700°C or above, becomes a challenge. For example, a label with barcodes applied, at a room temperature, on a metal or ceramic part must be readable with a scanner after going through a high temperature processes.

Green ceramic sheets have been used as label materials from the early 90's and several constructions of the green ceramic sheet have been patented<sup>1-7</sup>. The sheet material consists of fillers, such as glass frit, ceramic powders, and one or more binder resins including silicone resin. A label made from this sheet material can be applied onto an object that is then subjected to a high temperature. As a result, the binder resin and adhesive decompose and the glass frits of low melting points melt, or silicone resins undergo so called sol-gel reaction, causing the pigment to adhere to the object. The glass frits used here may flag an environmental concern since low melting point glass frits usually contain lead, while the silicone resins (in both ink receptive layer and base layer) may affect THT (thermal transfer) printing quality. However, it is very difficult, if not impossible, for a label to fuse and adhere on a substrate without the help from glass frits of low melting points and/or silicone resins. It is also difficult to make one green ceramic label work on both ceramic and metal substrates because of the huge difference between coefficients of thermal expansion of metal and ceramic materials.

The object of this work was to provide a pre-ceramic label material which can be applied like a normal label and used for identifying both ceramic and metal parts during a high temperature (>700°C) process. Thus, a low cost and reliable method was proposed for monitoring a product before, during, and after manufacturing steps.

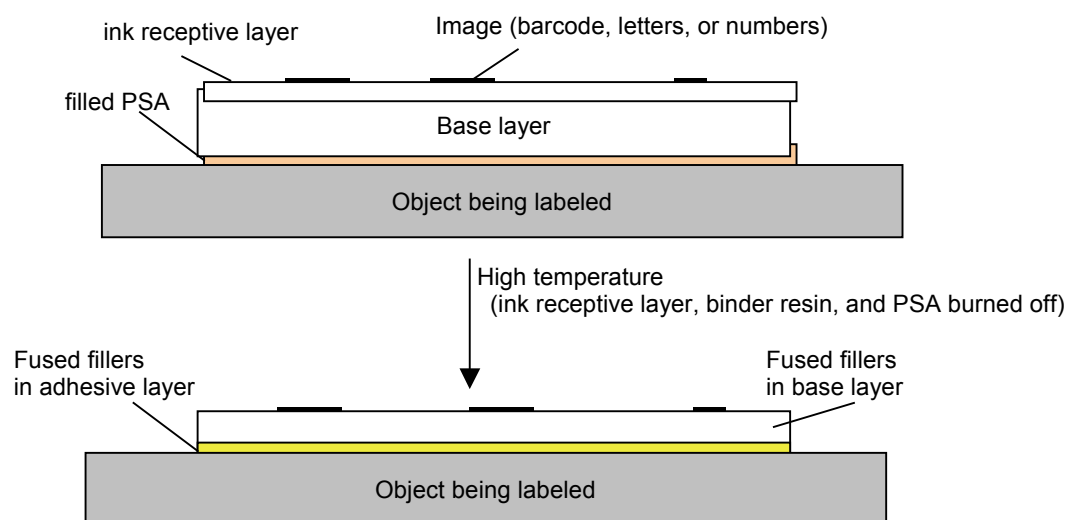
### Preparation of Green Ceramic Labels

The label material in this work was prepared according to reference No 8. The label had a three layer construction: an ink receptive layer, a base layer, and a filled pressure sensitive adhesive (PSA)

layer protected by a release film. The label was printed on a thermal transfer printer (Bradyprinter™ 600X-Plus) using a high temperature ribbon prepared in the lab. The printed labels were hand applied onto steel plates and ceramic tiles respectively. Then the labeled steel plates or ceramic tiles were placed in an oven at room temperature and the oven temperature started to ramp up at a rate of 23°C/min to predetermined temperatures 700°C, 800°C, and 900°C. After keeping at each temperature for 15 minutes, the oven was turned off and the sample was allowed to cool down to room temperature in the oven.

## Results and Discussion

At a high temperature process, ink receptive layer, the binder resin in the base layer, and the PSA in the adhesive layer all volatilized. The image fuses onto the top side of the label and the label fuses onto the substrate to be labeled (Figure 1).



**Fig. 1** Scheme of the application of a green ceramic label of the current work

### ***Effect of the Adhesive on Substrates Being Labeled***

The label material is ceramic in nature. It has a much different coefficient of thermal expansion than metal. Labeling on metals using a pre-ceramic label is a challenge. Figure 2 shows pre-ceramic labels using a PSA as received (unfilled) on a steel plate after being subjected to 700°C and 800°C for 15 minutes respectively. After the steel plate cooled down, the label cracked and fell off (Figure 2, top). However, by using a careful formulated adhesive, a much better result was obtained (Figure 2, bottom). On ceramic tile, the labels using both filled and unfilled PSAs adhered very well on the substrate after being exposed to high temperatures of 900°C (Figure 3, top). The barcodes were scannable. It was obvious that the filled adhesive functioned as a cushion between the ceramicized label and metal.



**Fig. 2** Pre-ceramic labels on steel plates after 800 °C (left) and 700 °C (right) for 15 minutes respectively: unfilled PSA (top) and filled PSA (bottom)

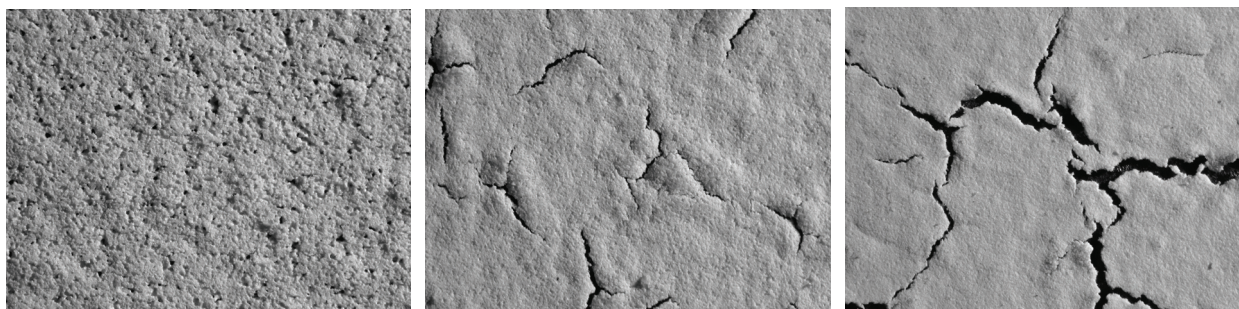


**Fig. 3** Pre-ceramic labels on steel (bottom) and ceramic tile (top) after treatment at different temperatures for 15 minutes (from left): 900°C (left), 800°C (middle), and 700°C (right)

### Effect of Particle Size

It was found that the final appearance of the label strongly related to the particle size of the powders in the base layer (as shown in Figure 4). The powders were ballmilled during compounding. The major peak values of the particles were around 15, 85, and 110 micron before ballmilling. After ballmilling for 10 hours, two major peak values showed around 0.2 and 3 micron. This may be explained by the internal stress generated when the fused particles cooled down. The smaller the particle size, the more intimate contact between different particles, and the more completed reactions between particles when the particles fused at a high temperature. That means a higher shrinkage of label and, thus, more cracks. Therefore, the particle size must be controlled to a optimum range to obtain a label with a good appearance after being treated at a high temperature.





**Fig. 4** Micro-view of labels on steel after being treated at 700 °C/15 min  
ballmill time (from left) = 2, 10, and 50 hours

### ***Effect of Ink Receptive Layer***

To obtain a high quality thermal transfer (THT) printing on the pre-ceramic label discussed above, an ink receptive layer is a must. The base layer is not smooth enough to guarantee the quality of THT printing since the layer is highly pigmented with powders. The binder resin is less than 30% (dry ratio). However, using an ink receptive coating layer can overcome the drawback and result in a smooth surface for THT printing.

It is vitally important to select a polymer for making this ink receptive layer since the image may go away when the ink receptive layer burned off. Acrylic polymers were chosen to formulate the ink receptive layer in this research. At a high temperature, unlike other polymers going to randomly break down along its backbone, acrylic polymers tend to decompose by the zipper mechanism, i.e. monomers leave from the polymer chain end one by one. The deduction is that the monomers are small enough to pass through the printed images layer without damaging the printed images. Polyester and polyurethane were tested as a ink receptive layer for comparison to acrylic polymer. Both polyester and polyurethane ink-receptive coatings were failed to maintain a good THT image after being treated at a high temperature ( $> 700^{\circ}\text{C}$ ).

### **Conclusion**

This work proposed a low cost, convenient method, pre-ceramic labels, to identify an object that need to go through a high temperature process. By carefully formulating each layer of the label, pre-ceramic labels can be applied for identifying both metal and ceramic parts. Since pre-ceramic labels survive in a high temperature process, they can be employed to enhance the control of process, inventory, and quality with implementation of an in-process barcode system.

### **Reference**

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2. USP 5,204,163 (Nakatsuka)
3. USP 5,209,796 (Sakuramoto)
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5. USP 5,578,365 (Kume)
6. USP 5,780,142 (Kume)
7. USP 6,416,845 (Kume)
8. USP Application 20070077384 (Yang)