

Polymer Innovations, Inc.

2426 Cades Way, Vista, CA 92081

Phone (760) 598-0500 Fax (760) 727-3127

PII Organic Termination Product Line

Polymer Innovations Inc. (PII) produces a kit of various ingredients to help in the formulation of termination pastes. The formulation of the organic portion of an end termination paste is quite challenging. The final paste must meet many properties such as good green strength and adhesion to avoid pin or abrasion damage during processing of the components. Probably the most daunting challenge is achieving good end termination cosmetics since there are many opposite characteristics which are required. The termination is typically applied to the chip by dipping. The termination must readily wet the chip but not wet the chip to the point of sagging end bands. The termination must flow and level on the chip but not to the point of sagging end bands or exposing the corners of the chip below. The termination must be stable and strong during the drying operation yet readily be removed during firing. The requirement of the organics burning out easily is further complicated by the inert atmospheres required for firing of copper terminations.

The organic components of the PII Cu termination kit have been selected to burnout cleanly even in the inert atmosphere used for firing copper. The components of the kit are listed below:

VT06: This is the main vehicle component and it consists of both high and low molecular weight resins dissolved in a slow drying mixture of terpineol isomers. Both resins were selected on their ability to burnout cleanly and to yield a strong and hard green coating.

TT01: This is a mixed isomer terpineol solvent used in the VT001 and used to dilute it further as required.

TX001: This material is a thixotropic paste and it serves two functions. Its main purpose is to increase the low shear viscosity and thixotropic nature of the paste. In this capacity it does not hamper the initial wetting of the paste during the dipping operation but it allows the paste viscosity to go up when the paste comes to rest to keep the termination end bands straight and prevent excess sagging during drying. The TX001 also contains an inorganic additive designed to promote a more controlled sintering of the metal powders added to the termination. This controlled sintering helps to prevent firing blisters, increases fired density and can help with final fired coverage of chip corners and edges. Other all organic thixotropic paste (TX003) is available if more thixotropy is desired but sintering changes are not desired.

TX003: As mentioned above these are all organic thixotropes. The TX003 should be incorporated by 3 roll milling into the paste. It is best to let the paste sit about 16 hours to let the viscosity stabilize before measurement. A typical usage level would be .5-2.5% of the TX003.

Inorganic Ingredients (supplied by customer): Typically the majority of the termination by weight is metal powder with a small amount of frit. The amount of inorganic to organic as well as particle size and morphology of the metal powder can have large effects on the termination and have a large effect on the organic composition needed. For this reason it is not possible to give an exact formula for the organics to use for a given metal and frit composition.

Typical Characteristics of PII's Primary Termination Vehicle:

| | <u>VT06</u> |
|--|--------------------|
| Approx. Viscosity kcps (HBT SC4 15/7R @ 20 rpm & 25°C) | 40 |
| Organic Solids | 34% |
| Solvent Boiling Point (°C) | 218 |
| Flash Point (°C) | 88 |

Typical Example Formula for Termination Paste:

Example* Termination Starting Composition

| | |
|---|-----------|
| Customer's mixture of metal powder and frit | 73.0 w/w% |
| VT06 Vehicle | 15.3 |
| TT001 Vehicle Thinner (solvent) | 10.3 |
| TX001 Thixotrope Rheology Paste | 1.4 |

All the ingredients can be batched together and stirred until powders are all uniformly wet out. The mixture can then be milled with a three-roll mill. In our recent experience with a particular inorganic mixture, we did not require a dispersant. However, if a dispersant is required, we have found DS007 burns out cleanly even in inert atmospheres.

*An exact composition cannot be given due to the unknown effects of the customer's inorganic mix and exact process needs. More experimentation and refinement of the formula above will probably be required.

Defects and Formula Development:

Defect Descriptions:

Mooning: When the termination runs down the sides of the chip making a half moon shape rather than straight edge bands.

Peaking: Typically the edge bands are very straight but the top or crown of the termination has a large peak or point on it.

Dimple: The top of the chip has a depression going across the top after drying. Frequently the thickness of coverage on the corners and edges of the chip may thin also.

Formula Development Procedure:

The process of developing the final formula for a provided composition can be time consuming and complicated since there are so many variables. We recommend starting with the composition provided above. The goal is to have the termination flow out enough to prevent peaking but not to the point where the termination creeps down the sides of the chip causing mooning or thin coatings on the corners and edges. These are opposite goals really. On the one side you need low viscosity and on the other side you need high viscosity for control. The way these two opposite objectives are reached is by thixotropy. That is to say during dipping the viscosity is low but when dipping is done and the termination is not being disturbed the viscosity of the termination increases at these low shear rates. The degree of thixotropy can be influenced by a number of parameters. Since thixotropy means viscosity is dependent on time and mechanical history, a paste right after being created on a roll mill is not entirely stable yet. Normally a much more accurate rheology can be determined after the material sits overnight.

For formula development, we would recommend making the starting composition given which could be a decent starting point for a termination formula which would not require blotting to reduce the effective thickness of the termination coating. It is safest to allow the paste to sit overnight to let the viscosity stabilize before testing but sometimes it is OK to test right away if one remembers the viscosity will usually become more thixotropic after ageing. The termination should then be tested on the chips. Usually hand dipping is the best way to evaluate the paste since it is quicker and uses smaller amounts of paste. The terminated chips are then evaluated for cosmetics and the formula can be adjusted to improve the performance. Some guidelines are given below:

The cosmetics are too peaky: This could be caused by too high of a termination viscosity or the paste being too thixotropic. If the viscosity is too high the solids loading of the inorganic could be decreased, the amount of added vehicle in the organic phase decreased, or similarly the level of TT01 thinner increased. It is possible there is the need for an added dispersant such as DS007 to allow more interparticle flow in the paste due to coatings which may be on the metal powders. The inorganic phase itself can have a large effect also. Usually larger proportions of high surface area powders can increase the viscosity.

If the termination viscosity does not seem too high yet the parts are peaky from the material being too thixotropic then the amount of TX001 could be decreased or eliminated. Also from the metal standpoint a high amount of metal flakes and or high surface area powders can make the material too thixotropic.

If the cosmetics have mooning this is the opposite effect of peaking. The material is either not viscous enough or not thixotropic enough. The opposite of things mentioned above may help. That is to say for higher viscosity or thixotropy – higher inorganic loading, higher VT06 percentage, less TT01, more TX001 (or TX003), and a higher proportion of flake or high surface area powders will help.

Dimpling: Can be caused by a lack of organic solids in the paste which allows too much shrinkage of the material in the crown or it can be caused by the material starting to flow too much during the drying phase. In either case the outside of the termination may partially dry forming a skin but when the balance of the termination on the inside starts to flow from the heat the paste flows out of the crown area and down the sides of the chip. Sometimes the cause can be found by drying the same parts at a lower temperature for a longer time to see if the dimpling goes away. If the dimpling is present regardless of the drying conditions it would suggest the composition needs more VT06. If the dimpling is only at the higher temperatures the use of more TX001 or a higher ratio of flake may help.

The formula development may take the creation of many small samples to get the desired cosmetics. However, thanks to the ingredients, the burn out and physical characteristics should be good. Also make sure when the optimal composition is found the paste should be checked after sitting for a day or more to test stability. Also one must be careful to check the performance during scale up.

PII Vehicle Advantages:

- Good hardness and adhesion to chip characteristics for good green performance.
- Ability to burnout cleanly even in an atmosphere not containing oxygen or air.
- Most cosmetics can be controlled through proper levels of ingredients.
- Components come prepared and QC tested.

Polymer Innovations, Inc. cannot anticipate all conditions under which this information and this product, or the products of other manufacturers in combination with this product, may be used. Polymer Innovations, Inc. accepts no responsibility for results obtained by the application of this information or the safety and suitability of this product either alone or in combination with other products. Users are advised to make their own tests to determine the safety and suitability of this product or product combination for their own purposes. Polymer Innovations, Inc. liability is limited to the replacement value of the product listed above.