Fine Patterning Technology with Screen Printing

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Abstract

The screen printing is used in a variety of production processes in the pattern formation of the conductor, the semiconductor, and the insulator material of electronic parts.

Science and technology development is necessary because it is an energy conservation production method in the future.

As for products such as our keyboard, GlidePoint,TM and Low-profile Operation Panels, the screen process printing is applied.

Here, it reports on the relation between Rheology and fine-patterning of the silver paste as part of the fine-patterning technology with the screen printing.

The screen printing is a system that combines various parameters like the characteristic of the ink , the characteristic of the mask, and printing conditions, etc.Therefore, it is said that it will not be easy to develop academically. In addition, the dynamic behavior of ink changes by each material to mix various materials with the product.

One method of understanding the characteristic of this ink includes the viscoelasticity measurement with the Rheometer.

We obtained the Ag paste that formed a fine pattern easily in the screen process printing by measuring the Shear stress to the frequency dependency and the Shear rate. As a result, the mass production of 0.1mm line & space was achieved on the PET film now.

Introduction

The screen printing process is one of the energy conservation production methods. and This is complete additive methods, and is used in a variety of production processes in conductors, semiconductor, and insulator of electronic parts for the pattern formations. Because the screen print technology is a classic technology, it is ability shortage against needs of making fine patterning in recent years. It is thought that science and technology development is necessary to make the best use of an advantageous point of the screen process printing further. The screen printing process is a system that combines various characteristics like ink, the mask, and printing conditions, etc. used. A lot of technological approaches have been done to the Fine patterning formation so far. [1]However, the reality is often done by worker's know-how. Because ink is a compound as one of the reasons why the screen printing process is not progressed easily in the science and technology, it is enumerated that the grasp of physical properties of Ink is difficult. In addition, physical properties of ink change by each material to mix various materials with the product. We have used to static viscoelasticity in the determination of viscosity as a method of understanding physical properties of this ink. It cannot know dynamic viscoelasticity behavior. The relation between dynamic viscoelasticity behavior and the fine patterning screen print becomes important when considering about the behavior of the ink at screen printing. [2] However, the thesis that investigates the dynamic viscoelasticity behavior and the relation of the printing property of a fine pattern is few.

On the other hand, and in the rheology study, there are a lot of documents of the dynamic viscoelasticity behavior to one kind of polymeric material. [3]However, the document of the dynamic viscoelasticity behavior to ink that mixes materials is hardly seen.

The purpose of this thesis is to clarify the relation between the dynamic viscoelasticity behavior of ink that is the compound of a lot of materials and the fine pattern formation with the screen process printing.

Theory

As for the viscoelasticity behavior of ink, the following models are used and evaluated.

When the Maxwell model is regarded, dynamic storing elasticity rate G'(ω) and dynamic loss elasticity rate G' '(ω) of a dynamic viscoelasticity is generally shown by the following expressions.

$$G'(\omega)=G\cdot\omega2\tau2/(1+\omega2\tau2) \quad (1)$$

$$G''(\omega)=\eta'\omega=G\cdot\omega\tau/(1+\omega2\tau2) \quad (2)$$

G; complex modulus,
ω; Frequency,
τ; Relaxation time
G'; Dynamic modulus and
η'; dynamic viscosity

When this equation is used, G', η' becomes the Figure 1.

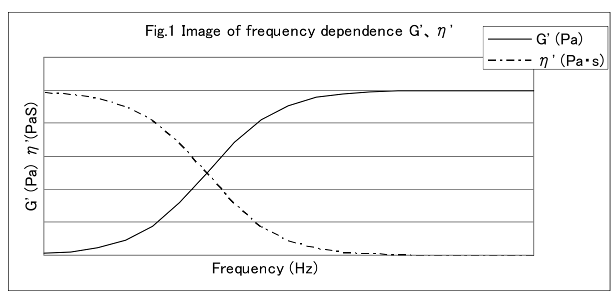


Figure 1

Next, it is thought that the stress of the viscoelasticity behavior of the ink when printing in the following order.

1. Scraper expands ink.
2. Ink passes the mask.
3. The mask part with the substrate.
4. Ink is a resting condition.

As for the state of 2, a big share rate is given. Because the mask is passed, the viscosity of ink may be low.

In the state of 4, the share rate doesn't gain. Because the printed shape is maintained, the viscosity of ink should be high.(1)

This index is suited to the dynamic viscoelasticity measurement. The frequency is assumed to be low of 2, and the state 4 assumes the frequency to be high. It is necessary that the Relaxation time τ is short, and η' on the low frequency number side is large for that.

Experiment

The viscosity measurement when the swerve speed changes like 1-4 is done, and ink that there is a difference in the viscosity change is selected first. Next, the relation between the behavior of η'to the frequency and the pattern that actually prints the screen is examined for the selected ink.

・The method of the determination of viscosity to the swerve speed do as follows.

Reometer : RAD-2 made by reometrix Roter; φ50

The numerical value at the swerve speed set as follows.

Whether the viscosity had changed was confirmed according to our plan.

1.100(1/sec)
2.1000(1/sec)
3.100(1/sec)
4. 0(1/sec)

Our company is executing this metrology.

We are calling this method sakuma-method.

・The measurement of η'was with same rheometer. The frequency response of G'G" was measured, and it converted it into G" to η'.

・The condition of the screen printing process was as follows.

Mask SUS#400 crender
Emulsion 10 μ m
Squeegee hardness 75
Squeegee speed 25mm/sec
Printing pressure 60kg/cm2

Result

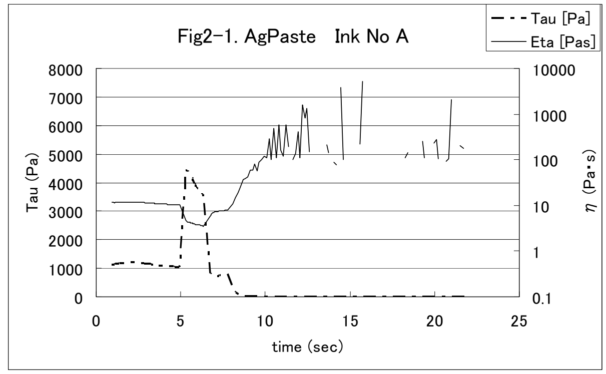
Hereafter, three kinds of data is shown.

It is a silver paste with a different manufacturer respectively.

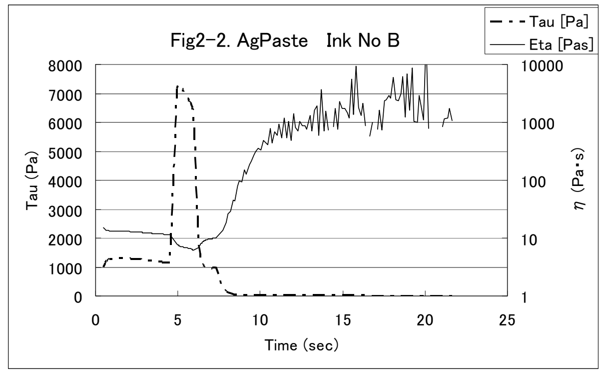
Elasticity modulus became as follows.

Ink No	Viscosity of No2	Viscosity ofNo4
A	3.5	300
B	6.2	1300
C	5.8	5000

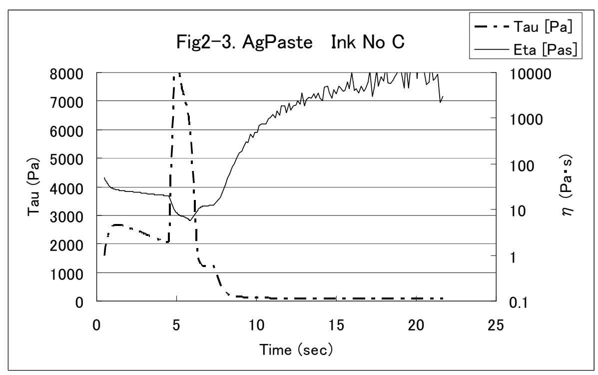
Ink A



Ink B



Ink C



Next, the frequency response of dynamic viscoelasticity was measured to request the dynamic viscosity η' of this ink, and the Relaxation time τ was requested by fitting of the Maxwell model.

Ink No	τ (sec)
1	1. 4
2	0. 16
3	0. 15

Ink A

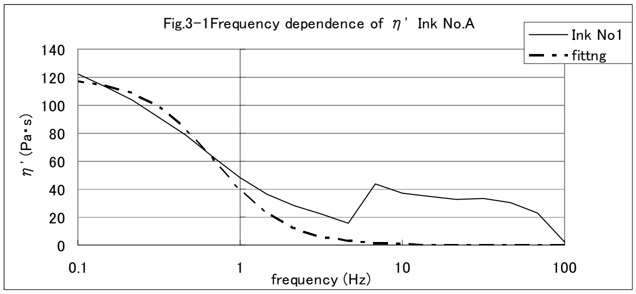


Fig.3-1Frequency dependence of η' Ink No.A

InkB

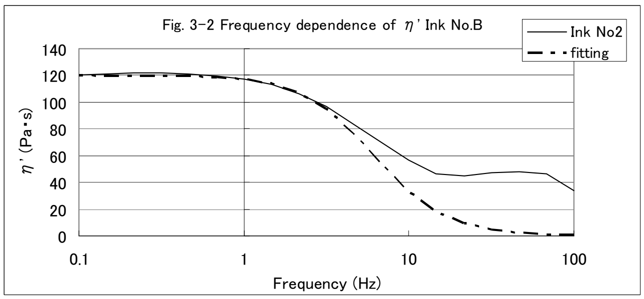


Fig. 3-2 Frequency dependence of η' Ink No.B

Ink C

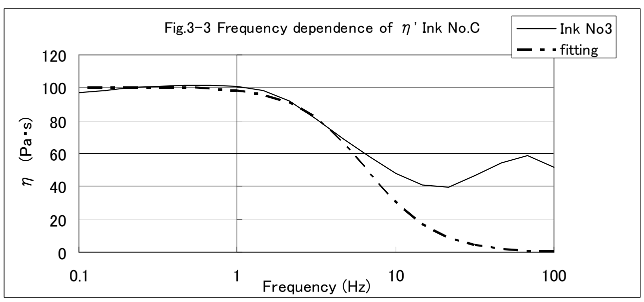
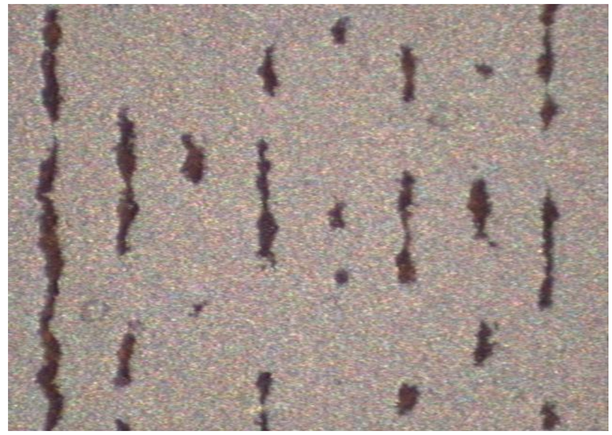


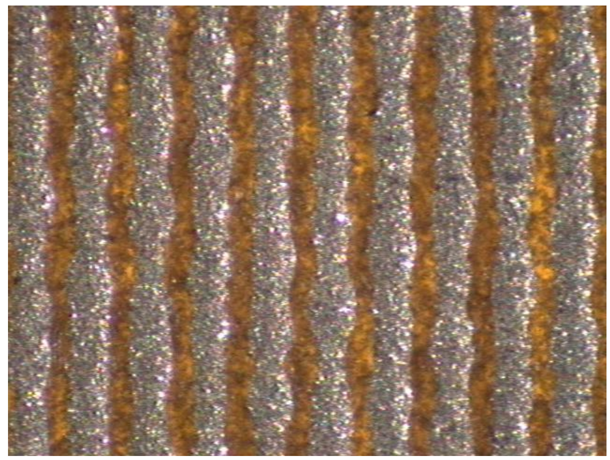
Fig.3-3 Frequency dependence of η' Ink No.C

In addition, We printed with three inks, and the pattern accuracy was confirmed.

Ink A



Ink B



Ink C

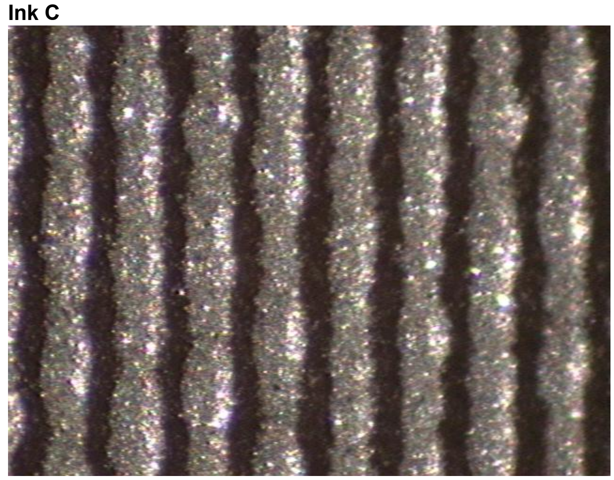


Fig 4 The print of 0.05/0.05mm Line/space

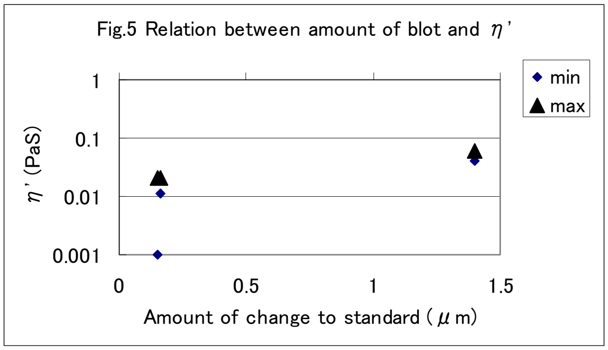


Fig 5. Relation between amount of blot and η'

Discussion

We did fitteing to the characteristic of η' this thesis. It has been understood that ink with good accuracy of the pattern tends the relaxation time short. This was as shown in a first prediction.

We were able to print the pattern of 25μm by using this ink C.

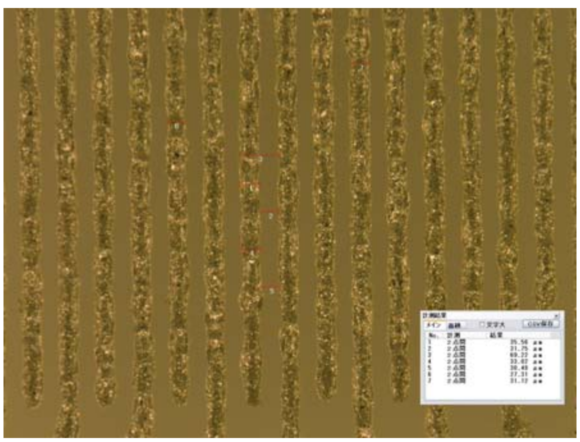


Fig. 6 25μm patterning with using Ink C

However, there are two problems about the frequency dependency of η'

- The peak seen in 10 to 100Hz is not made Fitting.
- Especially, it is ink of A and there are a curve of η'and a part that shifts greatly.

These inks are thought that the correction is necessary because it is a miscible system.

It is thought that correcting these and analyzing more detailed behavior are necessary. The application development extends if the relation between the relaxation time τ and the ink compound obtained according to this research results is examined. It is thought that deeper consideration can be done by enhancing the frequency measured by the conversion rule of time (TWF recentness).

Conclusion

The understanding of the ultra-high-density patterning technology with a screen process printing has improved in the present study. In addition, an important indicator in the ink selection was able to be obtained.

We want to apply this technology to not only ultra-high-density patterning, but also smooth patterning, etc. in the future.

References

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Author Biography

Heishiro Fudo received his BS degree in at The University of Tokushima (1998) And he received his master degree in material science at Japan Advanced institute of science and technology (JAIST) in 2000.

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