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A Study on Mechanical Strength of UV Curable Adhesive Sealant for LCDs

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Abstract

The feasibility of applying UV curable adhesive sealant to TFT-LCD was studied. The adhesive mechanical strength of LCD sealant was evaluated in comparison with the conventional thermosetting epoxy type sealant. The adhesive mechanical strength of the UV curable sealant, though slightly weaker than that of thermosetting epoxy type sealant, was found to be strong enough for actual LCD production after analyzing the actual stress that is generated in the during in the glass cutting process.

1. Introduction

The higher aperture ratio is essential to obtain the TFT-LCDs with a lower electric power consumption and a brighter display. An accurate alignment of the two glass plates; the TFT array substrate and the color filter substrate, during the adhering process of LCD panel fabrication, is the key factor in increasing the aperture ratio. The accuracy level is mainly governed by the positioning errors caused by the heat expansion difference between the two plates. To realize a higher accuracy of this positioning, there have been attempts to apply UV curable adhesive sealant instead of conventional thermosetting epoxy type sealant.

This paper describes the adhesive strength of UV curable adhesive sealants and compares this property with that of conventional thermosetting epoxy type sealant. Also, we simulated the highest stress induced between the sealant and the glass plate, during the glass cutting process. From the calculated stress, the minimum adhesive mechanical strength required for LCD panel fabrication was obtained.

2. Results of butt joint tensile tests

We evaluated three kinds of UV curable adhesive sealants and one thermosetting epoxy type sealant as a reference in this experiment. (Table 1) There are two types of the UV curable adhesive sealants. The one sealant requires only UV exposure for its hardening process and the other requires UV and heat.

A test sample form for tensile tests of butt joints is shown in Figure 1. The samples were made by the following steps; 1) A layer of the sealant with 6 μ m spacers was printed on the 1.1mm glass plate, 2) The second glass plate was bonded on the adhesive sealant, 3) The two glass plates holding a layer of sealant was cured by either UV light, heat, or the both. The glass plate was a low alkali glass designed for an ordinary TFT array substrate, and the UV exposure conditions were the same as those in the actual panel process in production. The glass plates were bonded to aluminum rods of 20mm diameter. The circular pattern of sealant was used

Table1. Sealant samples in this experiment

Sealant	Sample Curing Type	Curing shrinkage persentage*
Sample A	UV only	4 ~ 6 %
Sample B	UV & heat	2 ~ 3 %
Sample C	UV & heat	2 ~ 3 %
Reference	thermosetting	2 ~ 3 %

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to ensure a uniform tensile stress to the sealant.

The mean tensile strengths of butt joints for four kinds of sealant are shown in Figure 2. The strengths of thermosetting epoxy type are about 9 kgf/mm2. The mean tensile strengths of the UV & heat type are somewhere around 60 % of the one for the thermosetting epoxy type. Also we can see that the strength of the UV only type is around 20 % of the one for the thermosetting epoxy type.

The fractures of the samples after the tensile test are shown in Figure 3. The sealants themselves fracture for the UV & heat type and the thermosetting epoxy type, however, for UV only type, the sealant itself does not fracture but fractures at the resin-glass interface.

These results tell us that the mean tensile strength of UV & heat type and thermosetting epoxy type depends on the material strengths of the sealant. The mean tensile strength of UV only type is far weaker than the other types of sealant, since a larger strain grows at the boundary of the sealant and the glass plate during the curing process due to the higher percentage of curing shrinkage as shown in Table 1. The high strain at the boundary leads to the interfacial fracture.

3. Simulation results of the stress under the glass cutting process

The finite element method (FEM) was used to simulate the stress generated in the glass cutting process. The object of the simulation is to find out the stress-strain relationship among the sealant and the glass substrate.

The simulated vertical stress (normal Y) obtained by the glass cutting process is shown in Figure 4 as a contour map. In this simulation, the external stress is applied along the cutting line, and the sealant width is 1 mm, which is the same value of the tensile tests of butt joint. The normal Y at the edge of sealant is about 0.2 kgf/mm2. The tensile strength of the UV & heat type by butt joint test is twenty times lager than the stress obtained by the simulation. The UV only type shows only five times as much.

The simulation result tells us that the normal stress actually measured in the tensile test far exceeds the value obtained by the simulation. Moreover, the UV & heat type was durable from the actual glass cutting, when it was applied to more than one hundred TFT-LCD panels. This indicates that the sealants requiring both UV exposure and heating simultaneously provides sufficient adhesive strength applicable to actual LCD production.

Table1.Sealant Sample of this experiment

SealantSample	Curing Type
Sample A	UV only
Sample B	UV and heat
Sample C	UV and heat
Reference	heat curable epoxy sealant

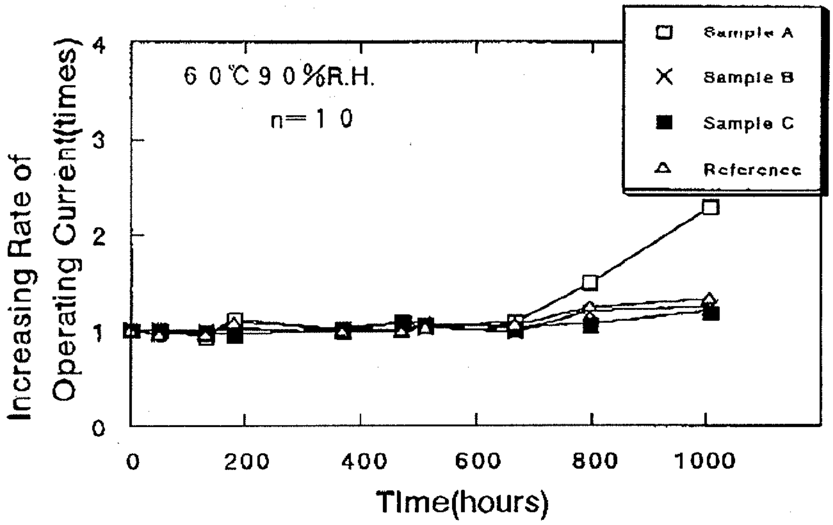

Figure.1 Examination of stability against humidety

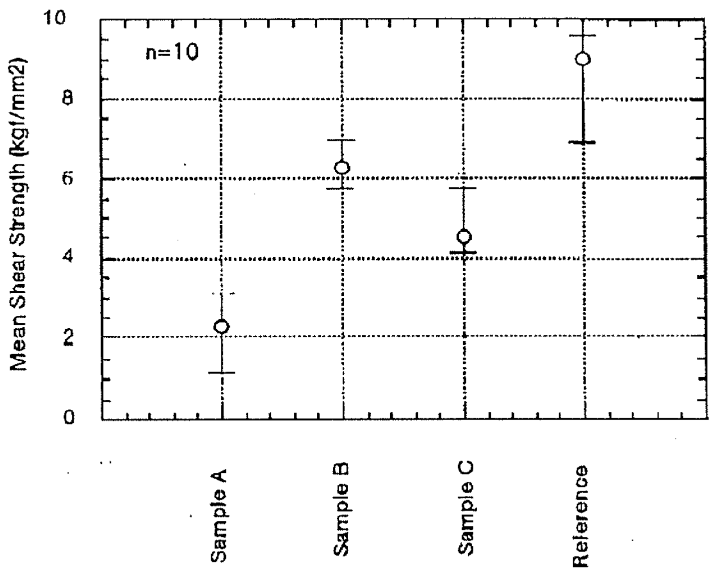

Figure.2 Mean shear strength of single lap join

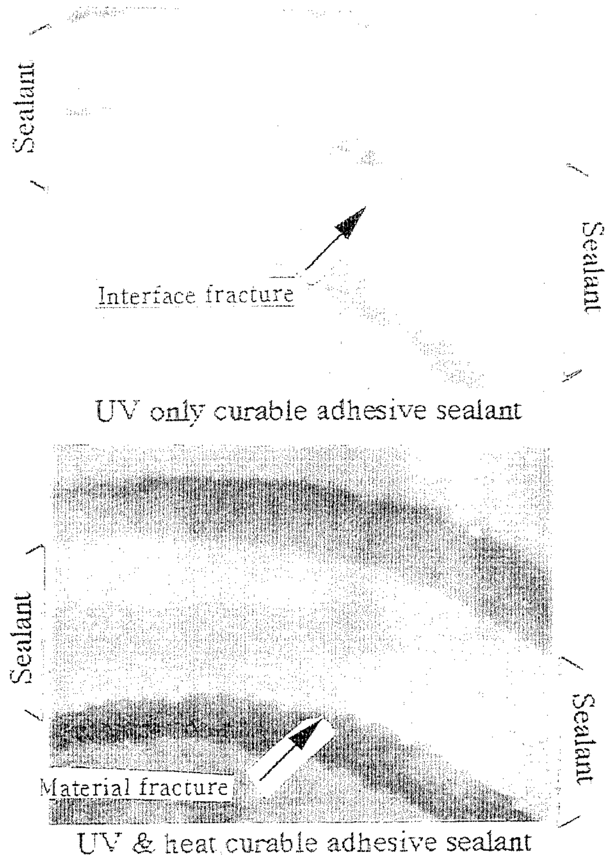

Figure 3. Photos of the fractures
after tensile test

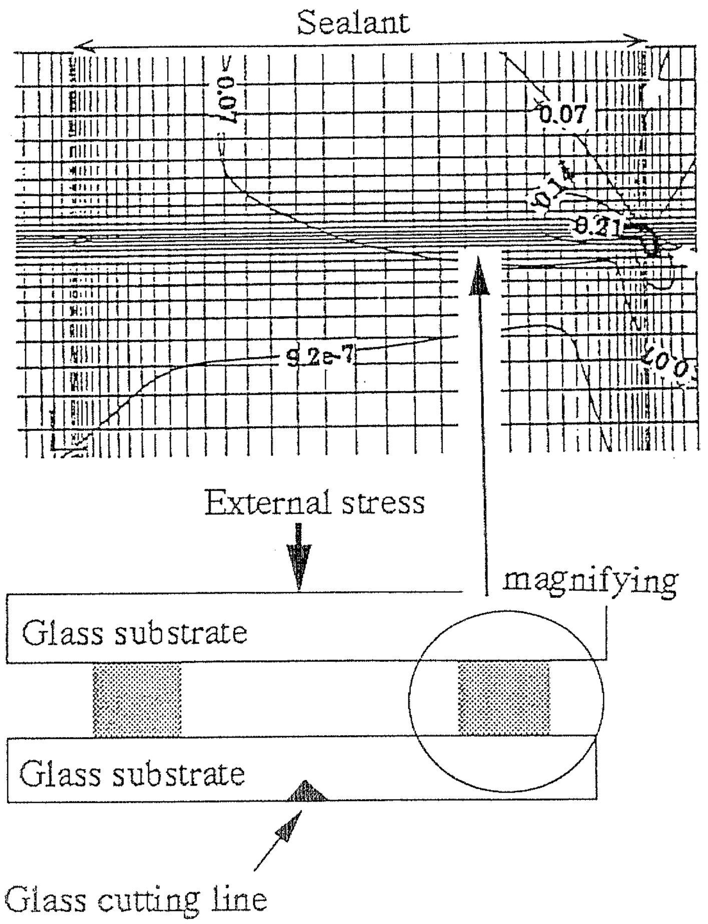

Figure 4. The contour map of normal Y obtained
from the glass cutting process simulation