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世界学术研究前沿丛书

Optoelectronic Technology

光电子技术

"世界学术研究前沿丛书"编委会
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Preface

Optoelectronic technology is the application of electronic devices that source, detect and control light, usually considered a sub-field of photonics. In this context, light often includes invisible forms of radiation such as gamma rays, X-rays, ultraviolet and infrared, in addition to visible light. Optoelectronics is based on the quantum mechanical effects of light on electronic materials, especially semiconductors, sometimes in the presence of electric fields. Optoelectronic devices are electrical-to-optical or optical-to-electrical transducers, or instruments that use such devices in their operation. Electro-optics is often erroneously used as a synonym, but is a wider branch of physics that concerns all interactions between light and electric fields, whether or not they form part of an electronic device.[1]

In the present book, thirty-five literatures about optoelectronic technology published on international authoritative journals were selected to introduce the worldwide newest progress, which contains reviews or original researches on Optoelectronic information technology, communications, optoelectronic technology, biological science and medical optoelectronic technology, military optoelectronic technology *ect*. We hope that this book can demonstrate advances in optoelectronic technology as well as give references to the researchers, students and other related people.

March 9, 2017

[1]From Wikipedia: https://en.wikipedia.org/wiki/Optoelectronics

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Contents

Chapter 1

Low Temperature Optodic Bonding for Integration of Micro Optoelectronic Components in Polymer Optronic Systems

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Abstract: Large area, planar optronic systems based on flexible polymer substrates allow a reel-to-reel mass production, which is widely adopted in modern manufacturing. Polymer optronic systems are fully integrated with micro optical and optoelectronic components as light sources, detectors and sensors to establish highly functional sensor networks. To achieve economical production, low-cost polymer sheets are employed. Since they are mostly thermally sensitive, this requires a restricted thermal loading during processing. Furthermore, a short process time improves production efficiency, which plays a key role in manufacturing processes. Thus, in this contribution we introduce a new bare chip bonding technique using light instead of heat to meet both requirements. The technique is based on the conventional flip-chip die bonding process. Ultraviolet radiation curing adhesives are applied as bonding material, accordingly a sideway ultraviolet radiation source, a so-called optode, is designed. Before implementing the concept, the light distribution in the contact spot is simulated to examine the feasibility of the solution. Besides, we investigate two different UV lamps regarding induced thermal influence on polymer substrate to choose one to be employed in the optode. Process factors, irradiation intensity and irradiation time are studied. Based on these results, the mechanical and electrical reliability of the integrated components is finally evaluated.

Keywords: Flip-Chip, Die Bonding, UV-Curing Adhesives, Optoelectronic, Component Integration, Low-Temperature

1. Introduction

With rapid development of modern information technology the demands of sensor systems for more reliability of signal detection and conversion, higher speed of data transmission, more flexibility of carrier materials, and lower cost of mass production are increasingly growing. Fully integrated, large area optronic systems based on planar polymer substrates are the innovative solution. Optronics implies the employing of optical or optoelectronic components as light sources, detectors or sensors as well as optical waveguides as transmission medium to create a fully optical system that is well-established for sensing, processing of signals and transmission of data. Polymer films with a thickness of a hundred micro meters as carrier substrate offer high flexibility so that the optronic systems allow a reel-to-reel mass production, which facilitates a highly efficient manufacturing process. Besides, polymer films can mostly be purchased on a low budget, which makes the production of optronic systems more economical.

To realize such polymer based planar optronic systems, one key focus is on the integration of optical or optoelectronic components into the thin polymer sheets. We employ the optical or optoelectronic components in form of bare chips. Given the fact that most polymer products are thermally sensitive because of their low glass transition temperature Tg, e.g. PMMA with Tg 105°C, PET 70°C and PVC 80°C, the thermal loading on polymer sheets must be restricted during processing[1]. Another particular aspect is the requirement of the high positioning accuracy of the bare optoelectronic chips. As shown in **Figure 1** left, a small tilt of the bonded laser diode may cause a great loss of light transmission into the waveguide[2].

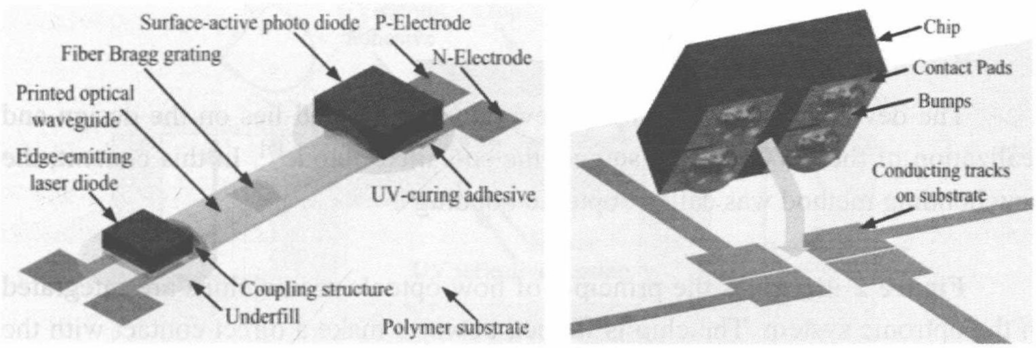

Figure 1. Left: Planar optronic system based on conventional semiconductor optoelectronic components; right: Flip-chip technology.

According to the state of the art in the field of chip mounting technology, there are two bonding methods available to accomplish the electric connections: wire bonding and flip-chip die bonding. In wire bonding technology, the chips are mounted face up, and the wires are used to build interconnections between the pads of chip and external[3]. Flip-chip die bonding is referred to as a mounting technology, in which the functional side of bare chip is faced down, and the pads on chip are aligned directly with the external circuit[4]. By this way, the electric connection is completed simultaneously with the mechanical mounting, which makes the whole bonding process much more efficient and cost-effective. Regarding the fact that optronic systems are built on a large area, flexible polymer substrate, wire bonding technology is excluded, since thin wire interconnections cannot withstand a variety of environmental disturbances. Thus, flip-chip die bonding technology is preferred.

In most applications of flip-chip technology, thermal effects are utilized, typically using solder bumps combined with hot air reflow or heat curing adhesives[5]. However, as already mentioned, thermal loading has to be avoided in polymer optronic systems to protect the polymer substrate from damage. With above considerations, we developed a new bonding method based on flip-chip technology using light instead of heat to realize the integration of bare optoelectronic chips into polymer optronic systems. Using light means applying ultraviolet curing adhesives (abbreviated as UV curing adhesive) as bonding material and getting it cured by UV irradiation. In order to enforce a stable UV irradiation during the curing process, a reliable UV radiation source is necessary.

2. Optodic Bonding

The development focus of this new bonding method lies on the design and realization of the UV radiation source, the so-called optode[6]. In this context, the new bonding method was called "optodic bonding".

Figure 2 illustrates the principle of how optoelectronic chips are integrated in the optronic system. The chip is flipped down to make a direct contact with the pads on the circuit while it is mounted on the polymer substrate. UV-curing adhesives serve hereon as bonding material mainly to assure the mechanical connection. Furthermore, some UV-curing adhesives contribute to electric contacting as well, e.g. isotropic conductive adhesive (ICA) and anisotropic conductive adhesive (ACA)[7]. Because of the danger leading to an electrical short of circuit, the ICA UV-curing adhesives are out of choice. ACA UV-curing adhesives are also excluded for the moment due to the shortage of the sorts on the market and the high cost of purchase. Therefore, in this work we employ non-conductive UV-curing adhesives. By triggering the optode, the UV rays are getting started to irradiate and will be guided in the direction of the spot of the adhesive. While getting the adhesive cured, the chip is getting mounted mechanically on the polymer films and electrically interconnected with the circuit.

2.1. Optode for Sideway Irradiation

On the basis of the concept shown in **Figure 2**, an optode serving as sideway irradiation was designed and is illustrated in **Figure 3**.

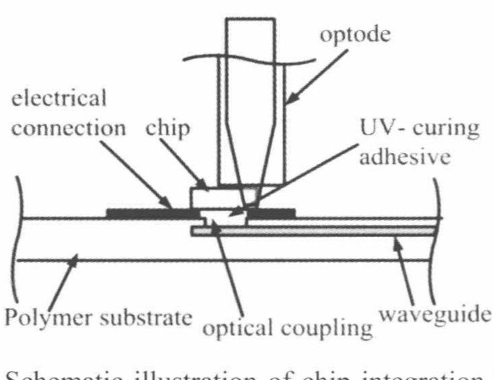

Figure 2. Schematic illustration of chip integration in optronic system using optodic bonding (Krühn T, 2012).

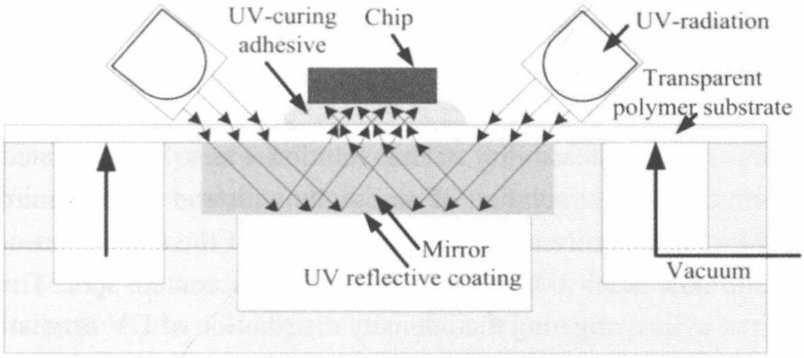

Figure 3. Schematic illustration of optode for sideway irradiation.

A manual flip-chip die bonding assembly system named *Fineplacer®* is used which is equipped with a heat plate as thermode for a conventional bonding process. To realize the optode illustrated in **Figure 3**, the heat plate has to be replaced by a newly constructed underplate. As a result, the vacuum configuration attached within the heat plate was eliminated as well, leaving the polymer films unfixed. This gives rise to unwished moving of the polymer films during processing. Even a tiny shifting can cause great positioning faults. Given this effect, we built a vacuum channel in form of a circle, which consists of many small holes around the bonding spot on the surface of the underplate.

The transparent polymer substrate lay on the underplate must have a sufficient transmission grade of UV irradiation. **Figure 4** shows the property of the transmission, reflection and absorption of the light in the UV range from 350nm to 400nm for the polymer substrates PET with a thickness of 200µm and the PMMA with a thickness of 175µm.

Polymer substrate PET-GAG has a sufficient UV transmission grade for the range from 350µm to 400µm. In contrast, for PMMA a UV transmission grade of about 80% starts only from the wavelength of 380µm. This optical property of polymer substrates has a significant effect on choosing UV-radiation source.

The chip is placed face-down, aligned with the conducting track on the polymer substrate after the UV-curing adhesive is dispensed on this contact spot. To accomplish the junction between chip and substrate, the key is the curing of the adhesive. However, because of the ultrathin thickness of the adhesive layer barely adequate UV rays can reach there to get the adhesive cured. To solve this problem, we place a mirror under the contact spot utilizing the principle of light reflection to collect sufficient UV irradiation.

As a first step, the feasibility of this solution was to be examined. For this purpose, we conducted a simulation of an optode with and without mirror. As simulation tool the software Zemax was applied. Aim of the simulation was to find out whether and how much UV irradiation reaches the contact spot. The question can be answered by investigating the intensity distribution of UV irradiation on the contact spot. The result presented in **Figure 5** shows a clear contrast between the simulation with and without mirror. The number in the figure has the unit mW/cm^2. In the left figure for the simulation without mirror, a blue circle can be seen that stands for an intensity of nearly 0mW/cm^2, *i.e.* no UV irradiation at all. In contrast, a red circle in the right figure that describes the simulation with mirror indicates an intensity of 7663.70mW/cm^2, *i.e.* sufficient UV irradiation. Therefore, the simulation

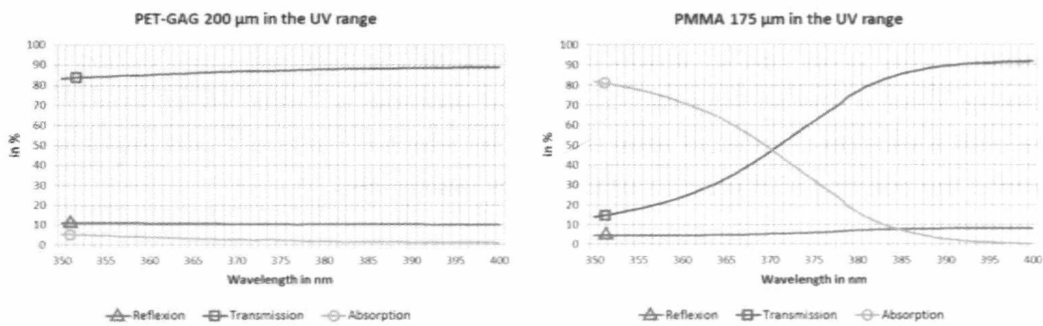

Figure 4. Light transmission, reflection and absorption in the UV range. left: PET 200µm; right: PMMA 175µm.

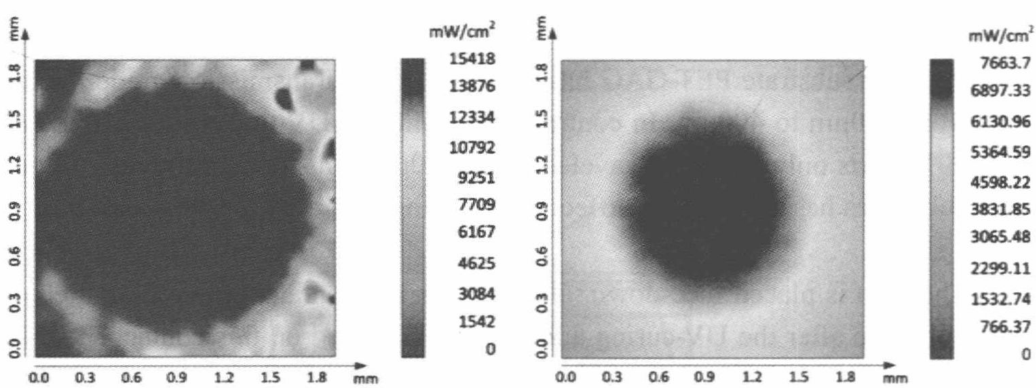

Figure 5. Simulation of the intensity distribution of UV irradiation on the contact spot from sideway optode. left: without mirror; right: with mirror.