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SELENIUM PHOTOCONDUCTOR FOR HIGH SPEED PPC

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1. INTRODUCTION

The electrophotographic process has progressed mainly as an important technology for Plain Paper Copying machines (PPC). Fuji Electric has developed selenium tellurium (Se/Te) photoconductors and selenium arsenic (Se/As) photoconductors which can be used in low to high speed PPCs. The high-speed (more than 70 copies per minute) PPC market, which uses the Se/As photoconductor because of its high sensitivity and high photo response, has grown especially. Recently, even higher-speed PPCs are becoming required in the market place.

Selenium arsenic (Se/As) photoconductors for use in high-speed PPCs are introduced in this paper.

2. OUTLINE OF Se/As PHOTOCONDUCTOR

Table 1 shows an outline of our Se/Te and Se/As photoconductors. Their sizes are varied so that may be easily incorporated into the design of PPCs. We have 4 kinds of Se/As photoconductors for high-speed PPCs as shown in *Table 2*.

3. PROPERTIES OF Se/As PHOTOCONDUCTORS

Se/As photoconductor uses As_2Se_3, a stoichiometric compound, which is structurally stable and has the following desirable properties.

(1) High sensitivety: Half decay exposure of 0.5 lx·s

Table 1 Outline of selenium photoconductors

Type of Photoconductor	Material	Layer structure	Major properties and features	Application
4C (4CR)	Se/Te	Se/Te Se/Te Al	◦ High sensitivity [E½: 1.5 - 2.5 lx·s by 2,850K white light source] ◦ Low fatigue [4CR denotes types with improved durability]	Plain paper copying machine (PPC) (low to medium speed and for drawings)
5A 5B 5E 5F	Se/As	As_2Se_3 Al	◦ Super high sensitivity [E½: -0.5 lx·s by 2,850K white light source] ◦ 5B and 5F are rough-surface types with improved cleaning performance. • 5E and 5F are types with improved high-speed response performance.	◦ Plain paper copying machine (PPC) (medium to high speed) ◦ Electrophotographic printers (medium to high speed) (applied for He-Ne laser and LED)

Table 2 Variety of Se/As photoconductors

Type of Photoconductor	Material	Surface of Photoconductor	Electrophotographic process		Application (PPC speed)
			Time between exposure and development	Mechanical stress at cleaning process	
Type 5A	As_2Se_3	Mirror	200ms≦	Small	Medium to high speed (30~60 copies/min.)
Type 5B		Rough		Large	
Type 5E	As_2Se_3 + Iodine	Mirror	50~100ms	Small	High speed (70 copies/min.≦)
Type 5F		Rough		Large	

Fig. 1 Spectral sensitivity of selenium photoconductor

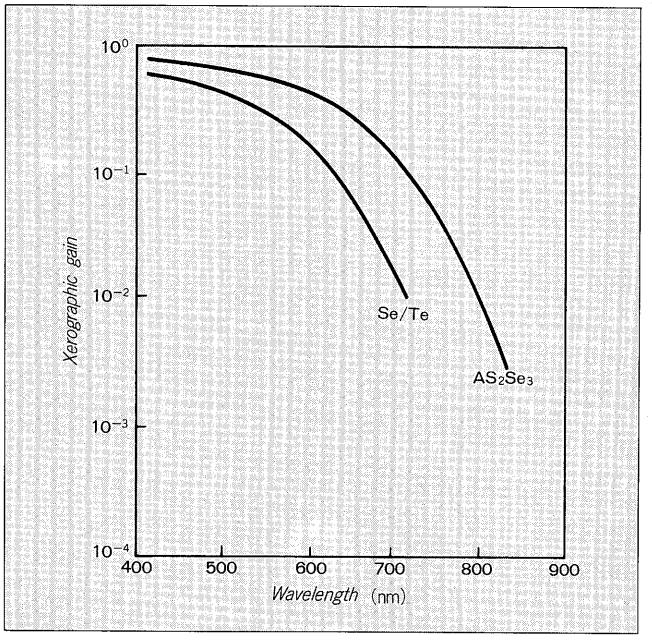


Fig. 2 Glass transition temperature of Se:As and Se:Te

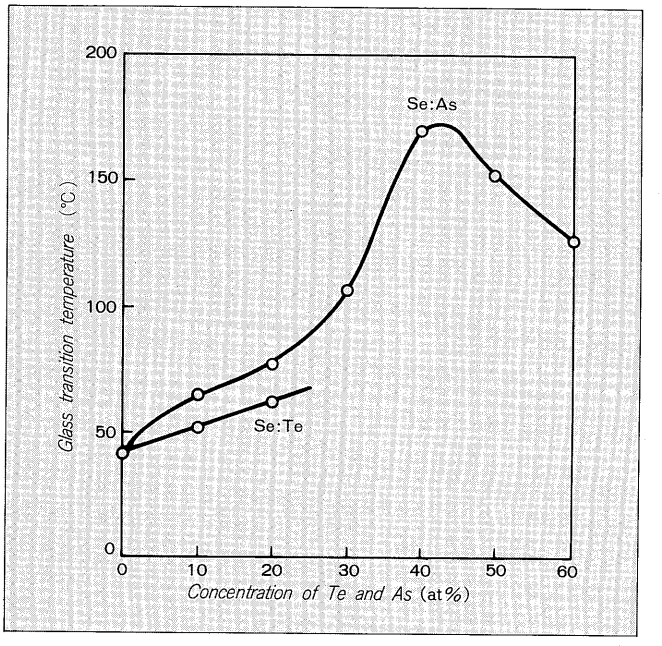
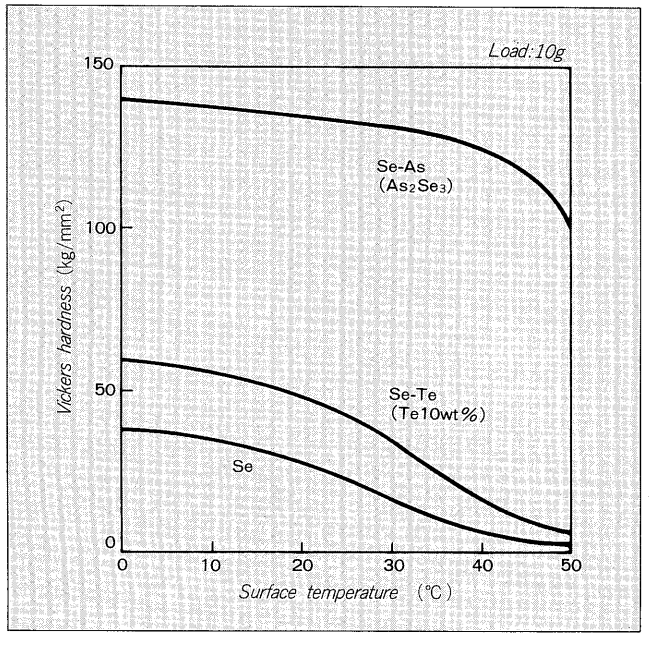


Table 3 Typical As_2Se_3 photoconductor specifications

Items		Major properties	
Electrical characteristics	Surface potential	600V - 1,000V (by corona charger, layer thickness: 60μm)	
	Sensitivity	Half decay exposure E½: 0.5 lx·s (by 2,850K white light source)	
Environmental characteristics	High temperature storage	55°C, 1,000h	No harmful change shall be made.
	High humidity storage	40°C, 80%, 2,000h	
	Low temperature storage	–20°C, 1,000h	
	Cyclic characteristics	–20°C → Room temp. → 40°C → Room temp. x 5 times	
Durability	The number of copies	More than 300,000 copies under the appropriate operation	

Fig. 3 Temperature dependence of vickers hardness



(2) High durability: Vickers hardness of 130 kg/mm²
(3) High heat resistance: Glass transition temp. of 170°C

3.1 High sensitivity

Figure 1 shows the spectral sensitivity of the As_2Se_3 photoconductor. The Se/As photoconductor has high gain (high sensitivity) even at long wavelengths (up to 700nm).

3.2 High reliability

Figure 2 shows the dependence of glass transition temperature on concentration of Se/As and Se/Te. *Figure 3* shows the temperature dependence of vickers hardness. The Se/As photoconductor has a high degree of hardness and high heat resistance, in other words, exhibits excellent reliability. Typical specifications of this photoconductor are shown in *Table 3*.

4. TYPE 5B AND TYPE 5F PHOTOCONDUCTORS

Figure 4 shows the typical electrophotographic pro-

Fig. 4 Electrophotographic process

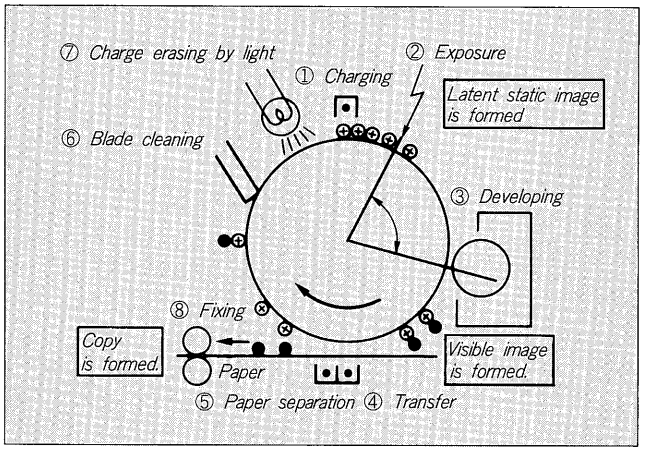


Fig. 5 Current curve of Se by TOF

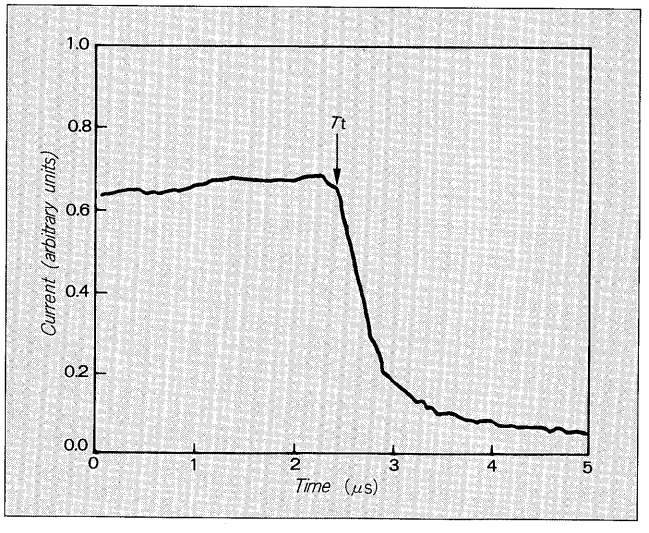


Table 4 Hole drift mobility and hole lifetime of selenium and selenium compounds

Material	Hole drift mobility ($cm^2/V \cdot s$)	Hole lifetime ($\mu \cdot s$)
Se	0.14	10~50
Se/Te Te5.4 at%	6×10^{-3}	25
As_2Sa_3	$1 \sim 2.5 \times 10^{-5}$	$2.4 \sim 6 \times 10^{3}$

cess. The cleaning blade exerts a large amount of stress on the photoconductor surface during the cleaning process. The surface is damaged by this stress, and results in copy defects. Type 5B and Type 5F photoconductors utilize an enhanced cleaning process to prevent the occurrence of these copy defects. The surface of these photoconductors are finished with ultra precision grinding using a grindstone to obtain a roughness of 0.1-0.7 μm. This type of surface

Fig. 6 Current curve of As_2Se_3 by TOF

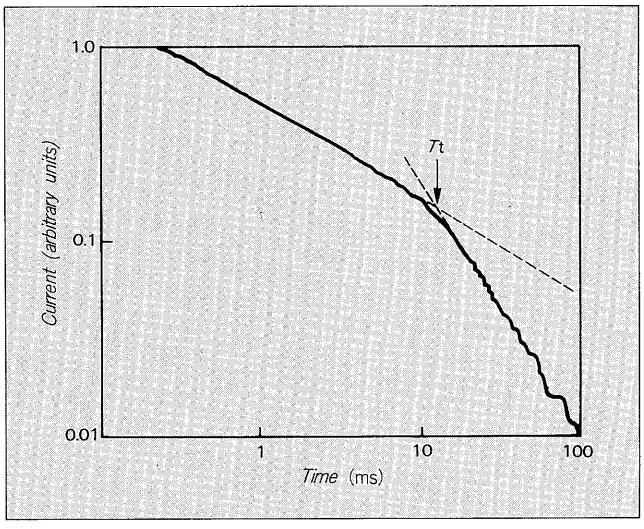
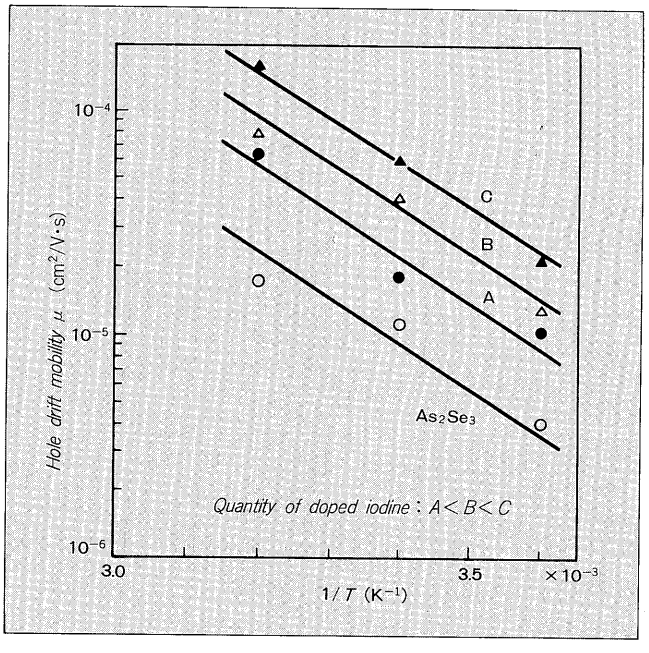


Fig. 7 Temperature dependence of hole drift mobility as a function of deped iodine quantity



structure will decrease frictional resistance. Type 5B and Type 5F are effective in enhancing copy quality and obtaining high reliability.

5. TYPE 5E AND TYPE 5F PHOTOCONDUCTORS

Light decay characteristics of a photoconductor are closely related to copy quality. The transport characteristics of a carrier generated by light have a great effect on the electrophotographic process. *Table 4* shows the hole drift mobility and the hole lifetime of selenium and selenium compounds. *Figure 5* and *6* show the current curve measured with the TOF (Time-Of-Flight) method. With As_2Se_3, it takes a long time to reduce the surface

Fig. 8 Temperature dependence of residual potential in As_2Se_3 photoconductor

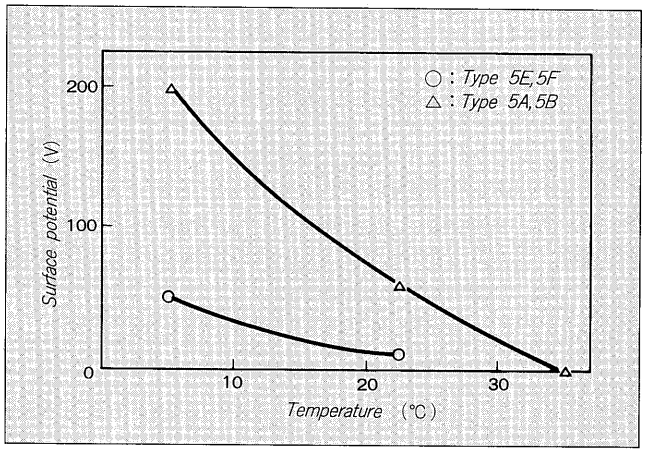
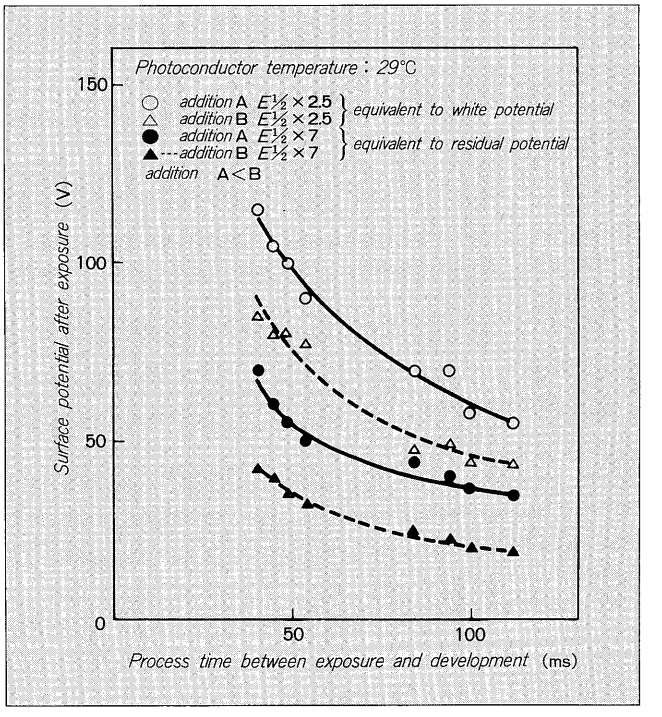


Fig. 9 Photo response of Type 5F photoconductor



potential of the photoconductor because hole drift mobility of As_2Se_3 is small and its carrier transport is dispersive. In the electrophotographic process, the As_2Se_3 photoconductor generally requires more than 200ms between exposure and development. This imposed a limit on increasing copy speed and making the PPC compact.

Type 5E and Type 5F have been improved in hole mobility. That is, the localized state in the photoconductive layer which hinders carrier transport is compensated by iodine doping. *Fig. 7* shows the temperature dependence of the hole drift mobility of As_2Se_3 as a function of doped iodine quantity.

As shown in *Fig. 8*, Type 5E and 5F have lower residual potential than Type 5A and 5B, especially at low temperatures. *Fig. 9* shows the photo response of Type 5E and 5F. Process time between exposure and development was reduced from more than 200ms to 50-100ms in these photoconductors, which can be used in high-speed PPCs of more than 90 cpm (copies per minute).

6. AFTERWORD

The As_2Se_3 photoconductor has been enhanced to satisfy the higher requirements of and keep pace with market place trends. PPC manufacturers will increase the number of high speed PPC as well as low through medium speed PPC models. High-speed PPCs capable of more than 70 copies per minute are currently being targeted by PPC manufacturers. Competition for faster copy speed will increase in the future. This will require even higher sensitivity and higher reliability in the photoconductor. Fuji Electric will strive to satisfy these requirements.