PHOSPHOR SELECTION CONSTRAINTS IN APPLICATION OF GATED FIELD-EMISSION MICRO-CATHODES TO FLAT-PANEL DISPLAYS

Andrei G. Chakhovskoi, W. Dawson Kesling and Charles E. Hunt
Department of Electrical and Computer Engineering
University of California, Davis CA 95616 USA
Ph: (916)752-0583, FAX: (916)752-8428

There are only a few generally available monochromatic and RGB triplet phosphors applicable to computer and television CRT displays [1]. Field emitter arrays fabricated using integrated circuit technology show promise as cold cathodes in low power, high image quality flat panel cathodoluminescent displays. But to obtain such displays, issues such as proximity beam focusing and cathode-screen spacing further limit the phosphor selection [2,3]. Only two major classes, common (high-voltage) CRT phosphors and low-voltage phosphors, are commercially realistic for flat-panel applications; the viable selection is listed in Table 1. High-voltage phosphors have low decay times and high light efficiency; low-voltage phosphors are significantly less efficient, with acceptable decay times.

Existing field-emission flat panel displays use a closely-spaced cathode-screen arrangement. This spacing limits the accelleration potential (without breakdown) to a few hundred volts [4]. This forces the usage of low-voltage phosphors with reduced efficiency and shorter lifetime. This class of phosphors is also considerably less well understood.

The alternative of using high-voltage commercial CRT phosphors (which decrease in cathodoluminescent efficiency at low voltages), in order to lower system power and reduce peak-peak gate voltage swings, introduces new constraints. The general standards concerning spot size, number of pixels and lines and resolution for commercial television and displays, as summarized in Table 2 [5], must be adhered to in flat-panel design. Computer simulations of proximity focused gated field emission devices [6] indicate resolution (roughly the inverse of pixel spot size) as shown in Fig. 1. Maximum anode voltage (limited by field strength) is given by $d(4x10^3)V$, where d is cathode-screen spacing in millimeters [7]. The tradeoffs between achievable resolution and maximum anode voltage may be adequate for some applications; however, secondary beam focusing will be required if high-voltage phosphors are to be used generally for all display types. Novel spacing techniques will be needed to accomodate the significant cathode screen spacing as well.

We are studying the effects of the phosphors listed in Table 1 on silicon field emission devices, both single-crystal [8] and polycrystalline [9] gated structures which we believe are applicable to large-area displays. Specific emphasis is given to the use of polysilicon as an emitter since this material is most readily adaptable to commercially manufacturable large-format arrays. This investigation addresses several issues: (1) the effect of Zn and sulfides in phosphors (high partial pressure), (2) the result of outgassing of binders and trace elements, (3) the effectiveness of phosphor encapsulation using differing conductive layers and (4) the long-term effectiveness of getters. We direct our study to noise characteristics and long-term cathode stability issues. We also are investigating how the selection of specific phosphors affects the design of the cathode array, the cathode-screen spacing and bias conditions. These above issues will be presented. We are also studying the effect of phosphor selection on system complexity and cost.

We present the current experimental results of this study as they impact the flat-panel display requirements we discuss here.

References:

1. K. Compton, "Selecting Phosphors for Displays", Information Display 5 (1), p.20, 1989
2. C. Curtin, "The Field Emission Display: A New Flat Panel Technology", Proc. of Intl. Display Research Conf., SID, San Diego, 1991, p.12
3. R. Meyer, "Recent Developments on 'Microtips' Display at LETI", Tech. Digest of IVMC 91, Nagahama, Japan, 1991, p. 6
4. F. Levy, R. Meyer, "Phosphors for Full-Color Microtips Fluorescent Displays", Proc. of Intl. Display Research Conf., SID, 1991, p.20
5. D. Eccels, G. Romans, J. Held, "HDTV: good for data?'", Information Display, 9 (1), p.16, 1993
6. W.D. Kesling, C.E. Hunt, "Field Emission Display Resolution", SID Intl. Symposium, 1993
7. W.D. Kesling, C.E. Hunt, "Field Emission Device Modeling for Application to Flat Panel Displays", J. Vac. Sci. Technol. B 11 (2), 1993
8. J.T. Trujillo, C.E. Hunt, "Fabrication of Gated Silicon Field-Emission Cathodes for Vacuum Microelectronics and E-Beam Applications", J. Vac. Sci. Technol. B 11 (2), 1993
9. A.G. Chakhovskoi, J.T. Trujillo, C.E. Hunt, "Investigation in PolySi Field-Emission Devices", unpublished, 1993

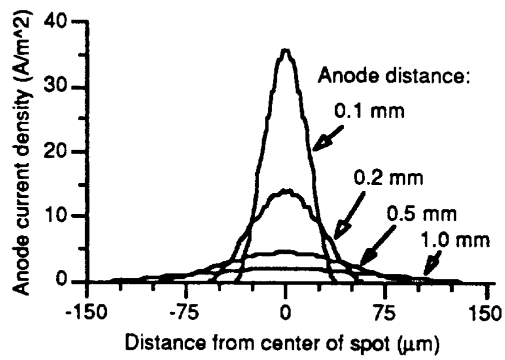

Figure 1.Simulated current density distribution at the anode for the unfocused pixel [7].

Table 1: Commercially available low-voltage and high-voltage phosphors applicable to flat panel displays

Type	Material	Color	Decay Time	Energy Efficiency	Excitation Energy
P22-Bl (a,b,c)	ZnS: Ag	Blue	30 - 50 µs	21 %	10-30 kV
P22 Gn (a,b,c)	ZnS: Cu, Al	Green	30 - 50 µs	17-23 %	10-30 kV
P22 Re (a,b,c)	Y_2O_2S: Eu	Red	~ 10 ms	13 %	10-30 kV
P15 G2 (a,b)	ZnO: Zn	Monochrome	8 µs	10 %	10 -1000 V
LDP-B3 (a)	ZnS: Zn + In_2O_3	Blue	-	1 %	10 -1000 V
LDP-G1 (a)	ZnS: Cu, Al +In_2O_3	Green	250 µs	3 %	10 -1000 V
LDP-R2 (a)	(ZnCd)S: Ag + In_2O_3	Red	150 -300 µs	4 %	10 -1000 V

Sources: a - Kasei Optonix Ltd., Japan; b - Riedel-de Haën, Germany; c - Sylvania GTE, USA

Table 2. Standard TV and computer display resolution requirements [5]

Character-istics	Graphics monitor	SVGA monitor	HDTV	VGA monitor	NTSC TV set
Pixels	2048	1280	1920	640	440
Lines	2048	1024	1035	480	485
Size (in.)	20x20	19 diagonal	34 diagonal	13 diagonal	27 diagonal
Resolution	102.4 DPI	~ 90 DPI	50-70DPI	~ 60 DPI	20-30 DPI