S 1-1. *Invited Paper:* To-Date Display Technologies and Devices in Russia (100 Years of Russian Electronic Displays)

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Abstract : History, recent results and trends of display technologies in Russia are reviewed. Main organizations dealing with both R&D and production of display components and devices are listed.
Key words: Russian and Soviet electronic displays, PDP, LCD, VFD, FED, OLED, projection, 3D

1 Milestones of Russian and Soviet electronic displays

- 25 July 1907 – Russian, Germany, and UK patent applications (Russian Privilege #18076) for the first electronic display – CRT for image displaying (Prof. Boris ROSING, Technology Institute (University), Saint-Petersburg).



B. Rosing V. Zworykin V. Frederickx

- 29 December 1923 – Vladimir ZWORYKIN filed a patent for a Television System based on iconoscope (a kind of kinescope), which produced pictures by scanning images (US Patent 2,141,059).
- 1926-1929 – Vsevolod FREDERICKX and co-workers (Alexandra REPYOVA and Valentina ZOLINA) have discovered a phenomenon of anisotropic fluids reorientation and changing their birefringence under action of external magnetic field.
- 1962 – Information Center of Space Branch, later Mission Control Center in Korolev, Moscow Region, including big screen (96 m^2), work stations, system "Telesviaz" (Telecommunication) with 100x300 video-switchboard.
- 20 February 1967 – an invention of the laser CRT filed in USSR (Author Certificate #V 3172) by Nickolai BASOV, Oleg BOGDANKEVICH, Alexander NASIBOV



N. Basov O. Bogdankevich A. Nasibov

2 Best recent achievements in R&D and production

2.1 PDP

a) Plasma Videomonitors with low pixel pitch (Fig.1)

Developer: PLASMA, JSC Research Institute of Gas-Discharge Devices (Ryazan)
The development is protected with 22 RF patents
Advantages:

- High resolution – pixel pitch up to 0.17 mm
- low switch time (<1 μs)
- wide temperature range (-60 ... +85˚C)
- high shock and vibration stability


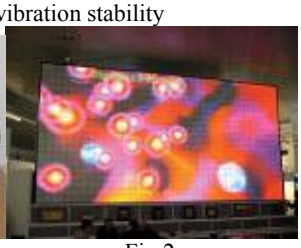

Fig. 1 Fig.2

b) Big tiled screens (Fig.2)

Developers and manufacturers:

- INCOTEX Holding Company (Moscow)
- R&D Institute of Nuclear Physics of MSU (Moscow)
- ELARA Co. (Cheboksary)
- JSC PLASMA (Ryazan) – manufacturing plasma modules

Performances: Tiled big screens with 19 cm and 41 cm modules with 3, 6, 12 mm pixels and brightness up to 1000 nit
Advantages:

- Very big size and high resolution are available
- Thin design
- Power saving circuitry

2.2 VFD, FED, CNT

Developer and manufacturer: R&D Institute VOLGA (Saratov)
a) **New VFD products**:

- Active matrix monochrome VFD
- Passive matrix color and monochrome VFD (Fig.3)
- Active matrix full-color VFD: 12" VGA and 14" SVGA, Brightness >400 cd m^{-2} in white

2.3 LCD

a) FLC:

- Ferroelectric LC with reduced switch time (<1 μs) and enhanced bistability
- Hysteresis-Free Passively Addressed FLC Display with Inherent Gray Scale

b) Universal transflective LCD (Fig.4)

Developer: Lebedev Physics Institute of RAS (Moscow)

Advantage: High light conversion efficiency

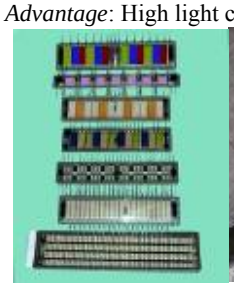

Fig. 3

Fig.4

2.4 OLED

a) Phenylene dendrimers for blue OLED

Advantage: increased luminance in blue

b) Tandem-diode amplifier-converter system

Developer: Lebedev Physics Institute of RAS (Moscow)

Advantage: high brightness, narrow emission spectrum

c) J-aggregates of nanoparticles

Developer: Frumkin Institute Electrochemistry of RAS (Moscow)

Advantages:

- Six narrow peaks of emission at 420, 500, 570, 590, 620 and 1150 nm
- Very saturated colors of emission
- Brightness >1000 cd m^{-2}
- Viewing angle >170°
- Temperature operation range -30°C - +50°C
- Switch-on time < 1 ms
- Increased heat and light stability

2.5 Electrochromic

a) All-solid electrochromic compositions:

Developer: Frumkin Institute Electrochemistry of RAS (Moscow)

Advantages:

- high electrochromic efficiency (ratio of optical density to the specific electrical charge),
- high rate of opaque/transparent transition (0.1-2 s),
- large number of working cycles (>10^6),
- operation voltage 1-5 V.

2.6 Projection

a) **Video walls** with 50", 67", 100" SVGA & XGA modules (Fig.5)

Developer: AR Technology Co. (Moscow)

Advantages:

- Flexibility
- Robust mounting system
- Low thickness of video wall (<47 cm)
- Almost invisible gap between the modules (<0.1 mm)

Fig. 5

Fig. 6

b) Laser CRT

Developers:

- Lebedev Physics Institute of RAS (Moscow), direct pumping
- AR Technology Co. (Moscow), reflective pumping

Advantages (LPI – multiquantum well system, Fig.6):

- Compact design
- Reduced anode voltage
- Output power 9 W (R), 2 W (G), 1 W (B)

2.7 Image processing

Developers:

- Samsung Research Center (Moscow)
- Research Center Module (Fig.7)
- Graphics & Video Lab, MSU
- R&D Institute Radio
- Demidov Yaroslavl State University (Fig.8)

Fig. 7

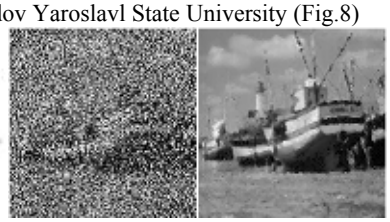

Fig.8

Developed algorithms:

- SuperResolution
- SuperPrecision
- Denoising
- Deblocking
- Local contrast

2.8 3D

Real 3D display with FLC shutters (Fig.9)

Developer: Lebedev Physics Institute of RAS

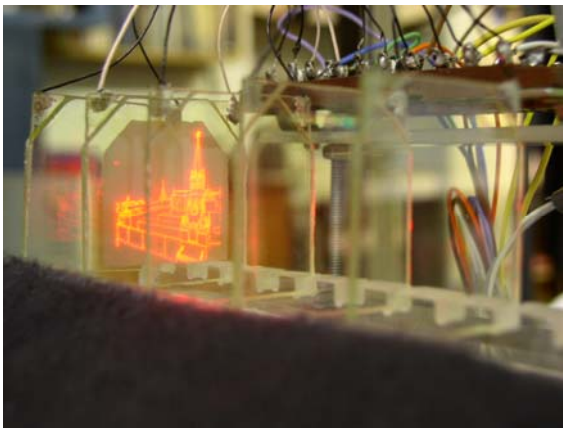

Fig.9

Performances:

- 2-D acousto-optic deflector
- Spatial resolution up to 500 x 500 points x 100 slices

3 Promising technologies

3.1 Phosphors

Developers:

- Saratov State University – VFD, FED, CRT
- North-Caucasian State Technology University (Stavropol) – CRT, VFD
- St.Petersburg State Institute of Technology – ELD (Fig.10)
- Shubnikov Institute of Crystallography of RAS (Columnar phosphors for FED – Fig.11)

Fig. 10

Fig.11

Advantages:

- High luminance yield
- Saturated colors
- Wide color gamut
- Increased stability of ELD phosphors

3.2 VFD, FED, CNT

a) New type of VFD and FED – Diamond-like planar-edge emitter (Fig.12)
b) CNT light sources
CNT Developers:

- R&D Institute VOLGA (Saratov)
- Physics Faculty of MSU (Moscow)
- Prokhorov General Physics Institute of RAS (Moscow)
- Institute of Radio-Electronics of RAS (Fryazino)

VOLGA (Fig.13):

- Size – up to 10 cm^2,
- Power consumption <10W,
- Peak brightness up to 200,000 nit,
- Light efficiency about 100 lm/W is feasible

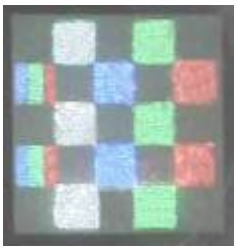

Fig. 12

Fig.13

3.3 LCD Backlight

Developers:

- Samsung Research Center (Moscow)
- Bauman Moscow State Technical University

Advantages:

- High light efficiency, brightness and color homogeneity
- Compactness

- Lebedev Physics Institute of RAS (Moscow), Fig.4
- Crysoptix Co. (Moscow; on the base of former Optiva) – Interference polarizer for LCD backlight

Advantage: 54% brightness enhancement

3.4 PDP

a) Gas discharge with high light efficiency
Developer: Institute of Applied Physics of RAS (Nizhnii Novgorod)
Performances: gas-discharge cells with radio-frequency addressing which have light efficiency 3-5 lm/W

3.5 DLP projectors

Developers:

- Samsung Research Center (Moscow)
- Bauman Moscow State Technical University

Advantages:

- Compactness
- Distortion level acceptable for HDTV

3.6 Flexible, E-paper

Developers:

- Lebedev Physics Institute of RAS – polymer network (Fig.14)

Advantages:

- Homogeneous texture of DHF cells.
- Cohesion ability to plastic substrates.
- High contrast ratio and low response time.

- MSU, Chemical Faculty – xerogel network (Fig.15)

Advantages:

- Pores dimension is tens nanometers (in PDLC, LCSP, capsulated films – tens micrometers).
- High content of LC in the composite (up to 90% in comparison with <60% in PDLC). The composite keeps rigid, flexible and elastic at the same time.
- Absence of liquid crystal material in the polymer network matrix

Fig. 14

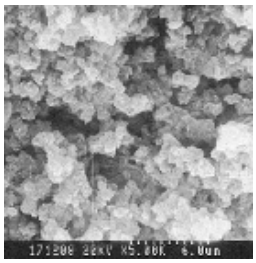

Fig.15

3.7 3D

Laser 3D Holographic Projection Display (Fig.16)
Developer:

- Tehnoproekt, S-Petersburg

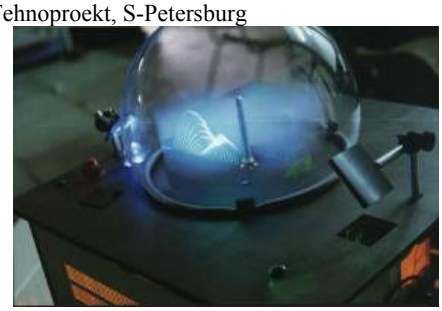

Fig.16

Performances:

- Volume frame rate – 25 Hz
- 2D resolution 500x1000
- Size of luminous dot – 0.6x0.8 mm
- Size of microlens array – 1 m x 1 m

4 Russian market of display components and products

In 2006 total Russian market of display products was estimated to be as high as $4.8 bln. The share of domestic products was ~1/4 of produced units. Main segments are TV sets (8 mln.) and monitors (7.2 mln.). 2006/2005 rates are as high as 190% (LCT TV), 167% (PDP TV), 148% (Projection), they exceed average world-wide rates.

Production of the TV sets in Russian fabs achieved the level of early 1990-s. Main production areas of the TV sets are Kalinigrad region, Moscow region and Voronezh.

5 Russian governmental programs

In 2000-s display business in Russia is supported in frames of governmental programs, and organization of technoparks and special economic zones (Kalingrad region, Zelenograd). Chief Russian manufacturers are Rubin, JSC Concern Scientific Center.

Basically, the Governmental support is determined by two programs. “Otobrazheniye-XXI” (Displaying-XXI) was started in 2006 in favor of Ministry of Defense of RF. Its target is development of unified sets of videomodules and organization of their production. Another program “Videomodule” is a part of scientific cooperation in frames of Union State Russia & Byelorussia in 2007 – 2010. Both programs are targeted to FPD including LCD, PDP and autoemissive, OLED and flexible displays.

Russian government proposed also to start a new national project “Development of domestic element base for electronics”. Proposed budget of the entire project is 40B rubles (~$1.5B). Possible share of display products in this program can be as high as 5-10%.

Prof. Vladimir KUKLEV – Coordinator of “Otobrazheniye-XXI” Program, SID Senior Member

Boris LEVONOVICH and Alexander VOITENKOV – coordinators of program “Videomodule” from Russia and Byelorussia, respectively

New developments of display technologies and products may appear as a result of new national program Nanotechnologies declared by RF President V. Putin in March 2007. Its total budget for three years is 180B rubles ($7.2B).

The sales of FPD TV sets and monitors will be increased after implementation of two other national programs: Digital TV Broadcasting in Russia and Internet to every settlement.