Fiber Optic Engine for Full Color Mobile Display

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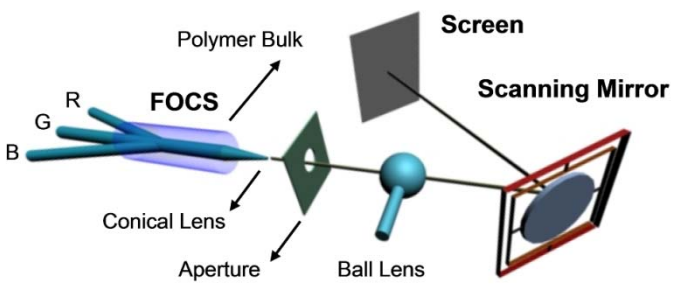
Abstract
In this paper we report a micro projector including of RGB sources, a 3×1 Fiber Optic Color Synthesizer (FOCS), and a two dimensional micro mechanical scanning mirror. We further report a modifier micro collimator which can enhance the resolution of the screened image.

1. Objectives and Background
Along with fast growth of high definition displays and mobile telecommunication network devices, there exist rapidly growing and compelling needs to combine those two in to one; near eye displays (NED),or equivalently head worn display (HWD) are considered to be very close solutions to combine display technology with mobile communication technology[1]. In order to comply with demands for small size and light weight NEDs, optical waveguides are being investigated especially in projection displays. Fiber optic color synthesizer (FOCS) has been introduced to provide wide color gamut using fused taper fiber coupler technology[2]. Recently a compact scanning micro projection display system has been introduced, where a micro optical waveguide was adopted in color rendering [3].In this study a micro scanning display optical engine is introduced, which consists of a fiber optic color synthesizer (FOCS), fiberized collimating lens, and a micro mechanical scanning mirror, along with red, green, and blue LEDs. In the end of FOCS a special lens tip was integrated along with a separate fiberised ball lens to enhance the working distance of the beam, decrease the beam size, and enhance the beam resolution on the screen. The potential of the proposed optical engine for LED-based NED is discussed.

2. Results
Fig. 1-1 shows the schematic diagram of the proposed device. The FOCS is three fused strands of hard polymer cladding fiber (HPCF) made by flame brushing technique. By using an arc splicer (Ericson FSU 975) a 3×1 coupler with a lensed-tip adiabatic taper[4] (Fig.1-2) whose diameter was 20 μm was fabricated in the output. In a similar manner a fiberised silica ball lens (Fig.1-2) whose diameter was 500 μm fabricated and was positioned at the effective focal length (400 μm) of the ball lens and this arrangement yielded a fiberised micro collimator.



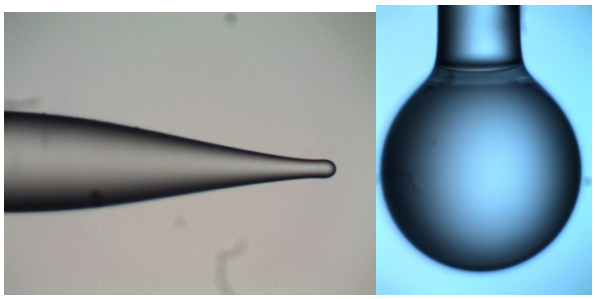
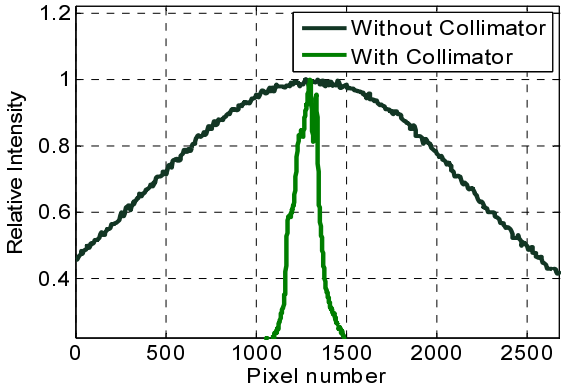


Fig 1-1. Schematic diagram of the mobile display. Fig.1-2: The lensed-tip adiabatic taper and the fiberised ball lens mad of coreless optical fiber.

In order to eliminate optical noise of the taper, a 30μm aperture was placed in front of the taper. The assembly of FOCS was immersed in PC-409 polymer then cured, which served as a cladding. Three red, green, and blue chip LEDs with the wavelengths of 640 nm, 524 nm, and 463 nm were used as light sources. The scanning micro mirror was a two dimensional scanning mirror (model: DM2Dk8, Hyperscan). The circular mirror was made of a thin high reflective aluminum with thickness of 30μm and diameter of 1.2 mm. Two function generators (HP

33120A) and a two-cannels fast amplifier (Model F20AD, FLCE Electronics) were employed to render 50 V_{PP} square waves with frequencies of 18.365 kHz and 2.615 kHz for periodic horizontal and vertical deflections of the mirror respectively. To characterize the fabricated all-fiber micro collimator assembly "*collimating strength*" was defined, which is the ratio of the divergence angle of the beam spreading out of a HPCF to the divergence angle when comes out from the proposed all-fiber micro collimator at a certain wavelength. By developing a program in MATLAB, and using second moment method[5], the spot size and the divergence angle of the beam were measured. The collimating strengths of the proposed device were 4.51, 4.28 for red 4.58, 4.53 for green and



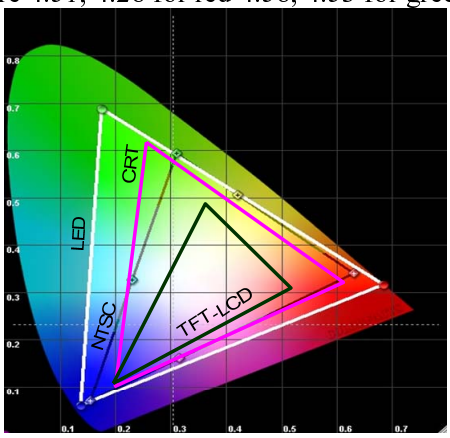


Fig.3-1: The effect of all-fiber collimating device for green color. Fig. 3-2: CIE 1931 diagram of the LED-based, CRT, NTSC, and TFT-LCD display.

4.62, 4.38 for blue, in the vertical and horizontal directions, respectively. As an example, Fig. 3-1 illustrates the relative intensity distribution of the green beam for two cases when passes through the proposed all-fiber collimator (light green line), and HPCF (dark green line). To estimate the color gamut of the display a colorimeter (CS-100A, Minolta) was applied. The CIE 1931 diagram of the proposed LED-based display was compared with those which belonged to NTSC, a typical CRT, and a TFT-LCD (Fig.3-2). The LED-based display has the most ample color gamut among other conventional displays.

3. Impact

A color synthesizer for micro scanning displays with low insertion loss and low power consumption was introduced. The proposed micro collimator can improve the beam brightness and retain the beam size in the far distance. The color gamut of the micro scanning display, shows that LED can be considered as a reliable source for NEDs.

4. Acknowledgements

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