

Evolution of Automated Turn-Key System for the Production of Rainbow and Reflection Holograms

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Abstract

We present details of a series of compact pulsed holographic camera systems that are designed for production of white-light-viewable reflection and rainbow holograms on the silver halide emulsions up to sizes of 110 x 150 cm. The series comprises a portable mastering camera **GP-MINI**, the studio cameras **GP-2J** & **GP-5J**, professional copying machines such as the **G3D** and **G3D-QF** and **HRIP™** digital mastering machines. All studio cameras work in rainbow and reflection copying modes as well as in mastering mode. The copy mode can also be used to produce copy holograms from masters written using digital data. Every camera machine is highly automated, providing instant switch-over from copying to mastering modes and permitting digital electronic setting of all beam ratios. All digital mastering machines integrate seamlessly into conventional computer networks.

Introduction

Since pulsed holography cameras were first introduced[1] both the fields of laser physics and holography have experienced significant development. First of all, Nd:YLF/Nd:Phosphate Glass pulsed laser systems[2] with easily scalable output energy from 1 J up to 32 J have been successfully developed. Secondly, the holographic technology of pulsed copying[3] has allowed one to integrate the mastering and transferring stages into a single compact machine – to make what we now call an automated pulsed holographic camera system[4]. In this paper we discuss the design of a family of advanced pulsed holographic camera systems. Some of these models are capable already of printing large-format full-colour holograms from digital data. It is shown that the pulsed approach not only eliminates vibration problems, but in addition ensures high productivity. Finally ultra-fast pulsed holography systems in conjunction with digital 3D-processing technology are shifting large-format holography towards the printing industry.

Analogue Holography Camera Systems

The GP x J series of analogue holographic camera systems are designed to record three-dimensional pictures of real objects. The GP x J series consists of three principle models that we routinely manufacture in addition to customized systems.

Figure 1. GP2J Holography Camera System with driving controller & power supply rack

The **GP-2J** machine (Fig.1) is used for mastering and transferring of holograms of up to 60 x 40 cm size. The system performs mastering and transferring either to monochrome reflection-type holograms (Red, Green, Blue, Yellow) or to transmission rainbow-type holograms. In addition the system is capable of generating digital full colour transmission rainbow holograms from masters produced by an digital mastering **HRIP™** machine (see below).

The **GP-5J** machine (Fig.2) is used for mastering and transferring of holograms of up to 100 cm x 140 cm (on film) and 60 x 80 cm (on plates). The system performs mastering and transferring either to monochrome reflection holograms or to transmission rainbow holograms. The system is also capable of generating digital full colour transmission rainbow holograms from masters produced by an digital mastering **HRIP**™ machine (see below).

Figure 2. GP5J Holography Camera System with driving controller & power supply rack

The **GP-Mini** (Fig.3) is a portable holographic camera designed for mastering only. Subsequent transfer is made in a GP x J system to reflection or transmission rainbow holograms. **GP-Mini** includes a cartridge & shutter assembly for day-light operation using film or plates and a film tension and roll advance system. The unit permits one to shoot holograms in any location if the maximal luminosity is below 400 Lux and requires an absolute minimum of space. The **GP-Mini** is transported and stored in stylish aluminum transport cases and does not require an external water connection for laser cooling. The maximum size of masters is 40 x 60 cm on glass plates or film.

Speed: of all these machines is 1 master per 3 minutes. In these specifications "x" refers to the energy in Joules that is provided by the Geola phase-conjugated single longitudinal mode Nd:YLF/Nd:Phosphate Glass laser that is built-in into each system. The output laser radiation in the green region of the spectrum (526.5 nm) is very close to the maximum sensitivity of the AGFA "millimask" plates and the SLAVICH VRP-M plates and film. The G x J laser's pulse energy is easily scalable from 1 to 8 J (and up to 32 J in custom models) over a pulselength of 30 ns. This energy enables the production of 3D holographic prints of sizes of up to 1.1 x 1.5 m. Custom systems are available for sizes of up to 2 m x 3 m. All camera systems are highly automated, providing instant switch-over from copying to mastering modes and permit digital electronic setting of all beam ratios. All camera systems have an optional auto-alignment system, energy meter with last pulse memory and wireless push-button remote control.

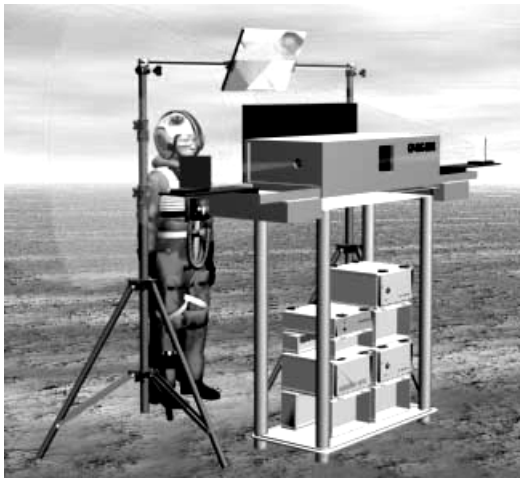

Figure 3. GP-Mini Portable Holography Camera System

GP x J camera systems are compatible with masters written by **HRIP**™ Holographic mastering machines (see below).

Digital Holography Camera Systems

All conventional 3D printing machines, including traditional embossed web printers and Geola's 3D camera systems, first require a master hologram to be printed. Once this master is available, "printing" or "copying" machines can use it to print 3D prints in commercial quantities. Until now however there have been no commercial automated machines capable of generating such required digital masters.

The **HRIP**™ is a Digital Image Processor which is similar in function to a Raster Image Processor (RIP) used in the Printing Industry. The **HRIP**™ takes a standard format 3-D computer file as input and numerically processes and converts this file into a digital master. The master hologram contains all the processed digital information in an optical form and is used by a either a Geola GP-xJ or by a Geola **G3D** Holographic Printing Machine (see below) to print the final large format 3D images.
All **HRIP**™ s are made with the standard functionality of a RIP: Queue management, a Web browser printer manager and Network administration. All of our **HRIP**™s are simple to integrate into an existing network environment with other printers and Rips.

The **HRIP**™ has two separate modules: Hardware Printer Module and Software Module.

3D Digital Mastering Systems: HRIP™

All **HRIP™** systems work according to the following scheme:

Step 1: Artwork Generation.

The 3D images required by the **HRIP™** and **G3D/GP-xJ** machines can be generated by any one of numerous commercial 3D Imaging programs currently available (e.g. Softimage™, Lightwave™, 3D-Studio™, P.O.V.-Ray, Bryce 3D™,VRML™).

Step 2: Mastering.

Once the 3-D image file is produced (this can be done remotely) it is sent via the network to a simple computer preprocessor where it is converted into a sequence of 2-D image files of BMP format (1024x768, 16 million colours). These files are then piped to the **HRIP™** which numerically processes the information contained in these files. When processing is complete the **HRIP™** prints the master hologram. Most of the final 3-D image properties are controlled at this stage - format, parallax, optimal viewing distances, gamma, diffraction efficiency, contrast, colour balance.

Step 3: Chemical Processing of the Master Hologram.

The Master exits the **HRIP™** in a light tight-cartridge. This cartridge is now inserted into a standard photographic processing machine where the Master is chemically processed and dried.

HRIP™ Maxi - a series of machines for the generation of digital masters suitable for the production of full colour transmission holograms and either monochrome or RGB reflection holograms. The HRIP™-MAXI is designed to be connected to the computer network and will allow standard 3D files to be spooled and printed to produce digital master holograms. The digital masters produced by this machine are suitable for the generation of 3D prints of format A3 (30 x 40 cm) to A0 (84 cm x 1.1 m) format. Larger sizes up to 2 x 3 m are produced by the **HRIP™-C**. The digital masters produced by these machines must be converted to 3D prints by a **G3D** or **GP-xJ** system.

HRIP™ Mini - a series of machines for the generation of digital masters suitable for the production of full colour transmission holograms and either monochrome or reflection holograms. This Holographic Raster Image Processor has been especially designed to fill the gap between embossed and photopolymer-oriented 3D printing applications. Until now most holograms in this sector have been made using either real models or by other time consuming technologies. The digital masters produced by this machine are suitable for the generation of 3D prints of format 2 x 2 cm up to A4 (20 x 30 cm). The digital masters produced by these machines must be converted to 3D prints by a **G3D-QF**, **GP-xJ** or third party printing system.

3D Printing Systems and Holography Cameras

These machines require digital masters produced by an **HRIP™** (H1) and work on film exclusively. Film is cheaper and easier to process for medium and large quantities.

G3D Series - machines for the transferring of digital masters to final full colour RGB rainbow transmission holograms (the final 3D print - H2). Sizes of final holograms produced are from A3 format to 2 m x 3 m. Speed from one 3D print per minute up to sixty 3D prints per minute.

G3D-QF - machines for the transferring of smaller digital masters (H1) generated by an **HRIP™-MINI** to full colour small format RGB rainbow transmission holograms and monochrome reflection holograms. Sizes of the final holograms are from 2 x 2 cm up to A4 format (20 x 30 cm). Speed from 60 prints per minute up to 1500 prints per minute.

The GP-xJ series have a lower speed but much more flexible and are orientated towards businesses that require either only analogue mastering or both analogue and digital - printing bureaus, photo studios, virtual prototyping bureaus etc. These machines are intended mostly for the short production runs from 1 up to a 1000 of holograms per run. The **HRIP/G3D** are orientated towards the printing industry with larger runs from 100 up to 500 000 holograms or up to and over a million holograms per run for the **G3D-QF**.

Applications

3D Holographic Systems in Science

The holographic systems described above have numerous scientific applications: Interferometry, Holographic Particle Image, Accurate Duplication and Archiving of Historical & Archeological Artifacts, Measurement, 3D Ultrafast Event Recording, Remote Inspection, Biological Tissue Analysis, Educational Uses, Digital Data Display and Archiving (Medical, Geology, Chemistry, Astronomy...)

For many of these applications there are available standard holography systems such as the analogue series GP-xJ and digital **HRIP™** produced by Geola uab, Lithuania. For HPIV are using our pulsed laser technology to make dual view orthogonal systems of any virtually size to customer specifications. For biological tissue analysis we are currently developing an near-IR variable coherence length Alexandrite-based mikro-holography camera system.

Medical Applications

GP-xJ analogue holography camera systems have important applications in medicine – such as in cranio-facial surgery where exact 3-D images of a patient's head can be of vital use to the surgeon.

Digital Holography systems also have multiple medical applications ranging from the effective display of tomographic data from MRI and CT scans to the superposition of proposed bone implants in an accurate 3-D model of a patient's face.

3D Printing Machines in Virtual Prototyping

Nowadays every manufacturing company uses CAD software with 3D capacities to design new products. With the release of Geola's **HRIP™** machines design bureaus and manufacturers can now print their prototypes in 3D. The **HRIP™** acts like a usual network printer when connected to the office computer network. You are then able to spool 3D files to this network printer and the **HRIP™** will print digital masters from 3D designs. These masters are then used to generate quick and high quality 3D prints using a GP-xJ system. Using the **HRIP™** and GP-xJ systems it is possible to print in real 3D in sizes from A4 format (documents) to 1 x 1 m (product presentation).

With a standard **HRIP™** digital mastering machine it is possible to generate within 10 minutes (not including rendering time for the CAD file which depends on graphical workstation) one monochrome master of any CAD or 3D design (colour holograms requires 3 masters to be recorded). Then you will need to transfer these masters to a final white-light viewable reflection hologram using a GP-xJ system. All this will require an hour for a virtual holographic prototype (VHP).

With the GP-xJ machines it is possible to make 3D prints of any physical model. Alternatively the model can be scanned using a third party 3D scanner and then a VHP can be printed via a digital master.

With digital holographic prototyping you can show limited animation which is encoded by reference to the position of the viewer's head relative to the hologram. As such, when the viewer moves in one dimension he sees the virtual model move, thus effectively demonstrating a vital function of the model. For example with virtual holographic prototyping you can demonstrate the building stages of a construction project, how a chemical reaction happens or how the suspension system of a car reacts to an impact. Virtual holographic prototypes are printed on holographic film and can be shared and sent. Only a standard halogen lamp is needed to replay full-colour 3D images.

Printing Industry

For the innovative printing, screen-printing or newspaper/book publishing company 3D printing machines can provide a mass production system for the generation of 3D prints for the following applications: Point of Sales Promotion, Cinema Film Promotion, Trade Booths and Exhibitions, Brand and Corporate Communication, Global Promotion and Advertisement, Indoor and outdoor Promotion, Posters, Decoration & Large 3D Prints. The appropriate systems for large quantities are the **G3D** and the **HRIP™-Maxi**. This combination of machines prints 3D prints with a speed of up to 60 m^2 per minute. For printing bureau or photo studio who need small and medium quantities GP x J machines together with an **HRIP™-Maxi** are suitable. For the following applications: Mass production of Stickers, Books covers Security Stickers, Mass production of small size 3D prints the **G3D-QF** with an **HRIP™-Mini** is the best combination. Moreover an **HRIP™-Mini** ensures production of masters compatible with existing embossed and photopolymer-oriented printing machines.

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Biography

Alexey Rodin received his M.S. degree in Semiconductor Physics from the Vilnius University in 1991 and a Ph.D. in Nonlinear Optics from Institute of Physics, Vilnius in 1998. Since 1991 he has worked in the Nonlinear Optics & Spectroscopy Laboratory in the Institute of Physics and since 1995 at GEOLA uab. His work has primarily focused on the control of solid-state laser radiation parameters and interaction of generated laser light with silver halide emulsions. Now he is a technical director at GEOLA uab.