hsfc pro
12 bit ultra speed intensified imaging

- four MCP image intensifier camera modules
- ultra fast shutter down to 3 ns in single mode
- excellent sensitivity of the system allows single photon detection
- 12 bit dynamic range
- ultra fast recording of up to 4 full frame resolution images with 1 ns interframing time
- four high resolution CCD image sensors (1280 x 1024 pixel)
- control PC with four PCI interface boards
- spectral sensitivity from VIS to NIR
- binning (horizontal & vertical)
- thermoelectrical cooling of CCD image sensor down to –12 °C
- optical or electrical triggering
- double shutter and multiple exposure (each module)
- serial high speed transfer via fiber optic link (FOL)
- free software camware for hsfc pro included

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hsfc pro

Having a single optical input, this ultra speed camera system comprises an image splitter unit, four intensified CCD camera modules with fast switchable MCP image intensifiers and high resolution CCD image sensors. Each module with its 12bit dynamic range and a high resolution CCD image sensor (SVGA) features an excellent signal–to–noise–ratio and the ability of single photon detection. Four high speed serial fiber optic data links connect the system to the PC. It can be triggered externally by light or electrical input. This ultra high speed camera system is perfectly suited for the imaging of extremely fast events, like hypervelocity impacts, short time physics, ballistics or combustion imaging.

technical data

	unit	setpoint	hsfc pro SVGA unit
resolution (hor x ver) [1]	pixel		1280 x 1024
pixel size (hor x ver)	µm²		6.7 x 6.7
sensor format / diagonal	inch / mm		2/3" / 11.0
peak quantum efficiency	%	depends on photocathode material	up to 50
full well capacity	e^-		25 000
image sensor			ICX085AL
dynamic range	dB	CCD + camera	69.3
dynamic range A/D [2]	bit		12
readout noise	e^- rms	@ pixel scan rate 12.5 MHz	7 .. 8
imaging frequency, frame rate	fps	@ full frame	8
pixel scan rate	MHz		12.5
A/D conversion factor	e^- / count		5
spectral range	nm	depending on photo cathode material (MCP)	160 .. 1300
exposure time	s		3 ns .. 1000 s
anti–blooming factor		@ 100 ms exposure time	> 1000
smear	%		< 0.005
binning horizontal	pixel		1, 2, 4, 8
binning vertical	pixel		1, 2, 4, 8, 16, 32
region of interest	pixel		down to 32 x 32
extinction ratio		@ 1 ms exposure time (CCD sensor)	1 : 2000
non–linearity (differential)	%	full temperature range (CCD sensor)	< 1
uniformity darkness DSNU [3]	count	@ 90% center zone (CCD sensor)	1
uniformity brightness PRNU [4]	%	typical (CCD sensor)	0.6

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technical data

	unit	setpoint	hsfc pro unit
trigger, auxiliary signals			electrical (TTL level)and optical (FOL) trigger
power consumption	W		150
power supply	VAC		90 .. 260
mechanical dimensions camera (w x h x l)	mm³		870 x 520 x 280 plus length of lens mount (without lens, appr. 170 mm)
weight	kg	camera	80
operating temperature range	°C		+5 .. +40
operating humidity range	%	non condensing	10 .. 90
storage temperature range	°C		–20 .. +70
optical input			Nikon F–mount, others on request
data interface			PCI local bus, Rev. 2.1, burst rate 132 MByte/s
CE certified			yes
cooled CCD temperature	°C		–12
cooling method			2 stage Peltier cooler with forced air cooling
interframing time	ns	two images on same module	500
photocathode material			S20, S25, GaAs, GaAsP, others on request
phosphor screen material			P43, P46
image intensifier pitch distance	µm		6
image intensifier MCP [5] type			single stage MCP
image intensifier diameter	mm		18, 25
image intensifier system resolution	lp/mm	@ 5 % MTF [6] typical (depends on phosphor)	> 60
shortest gating time	ns		3

[1] horizontal versus vertical
[2] Analog–to–Digital–converter
[3] dark signal non–uniformity
[4] photo response non–uniformity
[5] multi channel plate
[6] modulation transfer function

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input adapter	the lens input can be mounted along or perpendicular to the main instrument axis	
image splitter	four channels distribute 22 % of total incoming light to each module. The user can exchange beam splitter parts and mirrors to configure 1–, 2–, 3–, or 4–channel systems. All components are made in premium quality. The image splitter cubes are placed in the infinite ray path between the collimator lenses. The mirrors are mounted on strong spring loaded holders to absorb external shocks. Individual filters can be inserted in filter holders on each module for spectral range selection.	
image intensifier	type	HighRes MCP (6µm channel)
	output window	glass
optical coupling	“ultra speed tandem lens” between image intensifier & CCD transmission efficiency > 20 % vignetting < 3 % resolution > 60 lp/mm distortion free	
trigger modes	auto trigger	internal via software
	single trigger	internal / external
	continuous trigger	internal / external
shutter disable	high speed TTL inputs for disabling shutters (photocathodes) of each module, BNC connectors	
gate unit	ultra fast gating mode:	
	exposure times:	3, 5, 10, 20, 25, 30 ns, 30 ns .. 100 ns (10 ns steps), 100 ns .. 1 s (20 ns steps), 1 s .. 1000 s (1 µs steps)
	delay times:	0 ns .. 50 ns (1 ns steps), 50 ns .. 100 ns (5 ns steps), 100 ns .. 1 s (20 ns steps), 1 s .. 1000 s (1 µs steps)
	maximum pulsing frequency:	3 kHz
	highrate gating mode:	
	exposure times:	20 ns .. 1000 s (20 ns steps)

	delay settings:	0 ns .. 1000 s (20 ns steps)
	maximum pulsing frequency:	2 MHz
sensitivity	> 100 counts / photo electron with P43 phosphor > 20 counts / photo electron with P46 phosphor	
exposure modes	single exposure for ultra fast gating, multiple exposure function: (delay + exposure) x 1 .. 256 multi exposure for free programmable multiple exposures: (delay 1 + exposure 1,.., delay 10 + exposure 10) x 1 .. 256 double exposure for two full resolution images on each module, each exposure time 20 ns .. 1 s (20 ns steps), each delay time 20 ns .. 1 s (20 ns steps) time between two images on same module depends on phosphor decay time, the minimum delay time is 500 ns	
CCD integration time	1 ms – 1000 s selectable for adjustment to phosphor decay integration. Starts automatically, triggered by gate unit	
max. imaging freq.	for full resolution images:	
	4 images:	333 Mega fps (non–overlapping, 3 ns exposure time)
	8 images:	8 Mega fps (non–overlapping, double exposure mode)
jitter	at exposure and delay times < 100 ns: < 0.5 ns at exposure and delay times > 100 ns: < 5 ns	
camera interface	data transfer via fiber optic link (FOL), 4x double SC connectors, cable length 10 m (standard) .. 1500 m (optional)	
control unit	PC fully configured	
software	camware for hsfc pro software for camera control, display, storage and printing of image data under Windows9x, ME, XP, WindowsNT, Windows2000; software development kit (SDK) with demo software for the above mentioned operating systems	

phosphor data

phosphor	phosphor decay (typ.) to..		typical efficiency
	.. 10 %	.. 1 %	
P43	1 ms	4 ms	100 %
P46	0.2 – 0.4 µs	2 µs	30 %

photocathode characteristics

photo cathode material	peak wavelength [nm]	quantum efficiency at peak wavelength [%]	equivalent background input (EBI) [W/cm²]	dark counts [s^{-1}/cm^2]
S20 (multialkali)	430	14 .. 18	$3 \cdot 10^{-14}$	1500
S25 (multialkali)	600	8.3 .. 9.3	$2 \cdot 10^{-14}$	10 000
GaAs	530 – 750	23	$4 \cdot 10^{-14}$	30 000
GaAsP	480 – 530	50	$2 \cdot 10^{-14}$	10 000

spectral response of MCP

Spectral sensitivities of different MCP photocathode materials:
S25 (multialkali)
S20 (extended red multialkali)
GaAs
GaAsP

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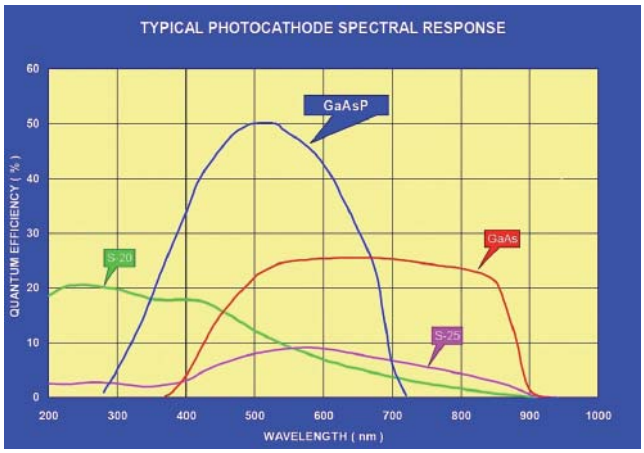
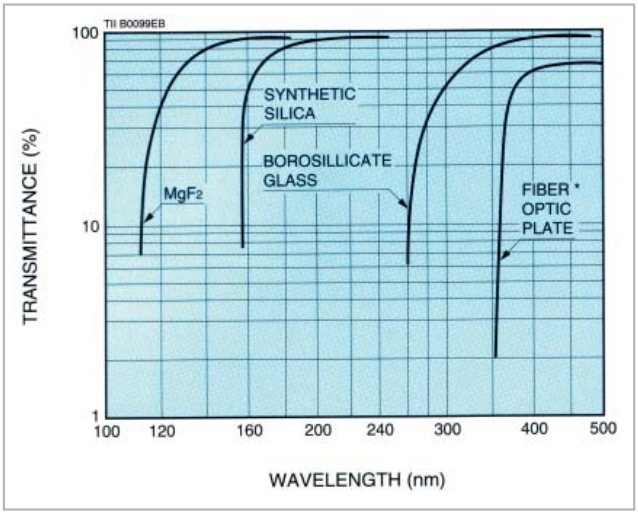


Typical transmittance of MCP window materials



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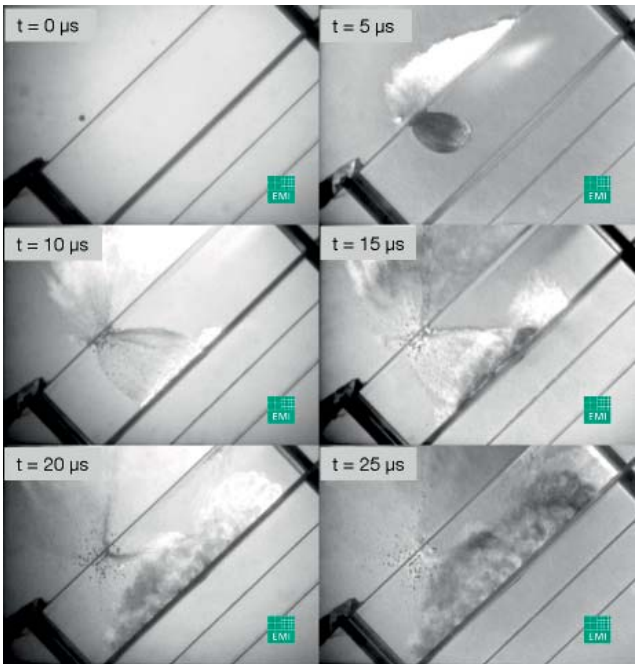
areas of application

- hypervelocity impact studies
- ultrasonic flame propagation
- laser ablation
- sparks in electrical switches
- short time physics
- ultra speed imagingballistics
- combustion imaging

example of application

The image sequence shows the impact of space debris on the shield of the automated transfer vehicle (ATV), which is an unmanned supply carrier for the international space station (ISS). The shield set-up was used at the Ernst-Mach-Institute together with its unique light gas guns, to investigate the fragment cloud dynamics and the damage caused by such space debris impact on the ATV, helping to optimize the shields.

...with friendly permission of: Fraunhofer-Institut für Kurzzeitdynamik – Ernst-Mach-Institut, Freiburg, Germany, www.emi.fhg.de



High speed imaging of an exploding Titanium wire. the purpose was the estimation of the temporal evolution of the plasma.

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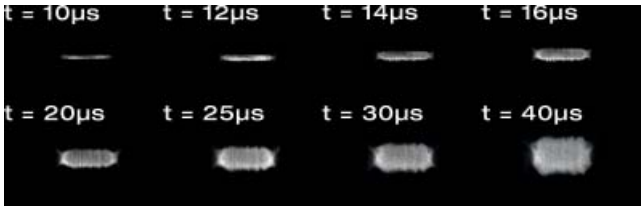

Contactless high speed metal forming by means of a pulsed electromagnectic field.
The forming process takes place in typical less than 70 µs, the camera exposure times were varied within one sequence between 500 ns and 2 µs to accommodate for changes in forming speed and light intensity due to metal reflections. The influence of the key process parameters magnetical field strength and mechanical setup on forming dynamics was studied.

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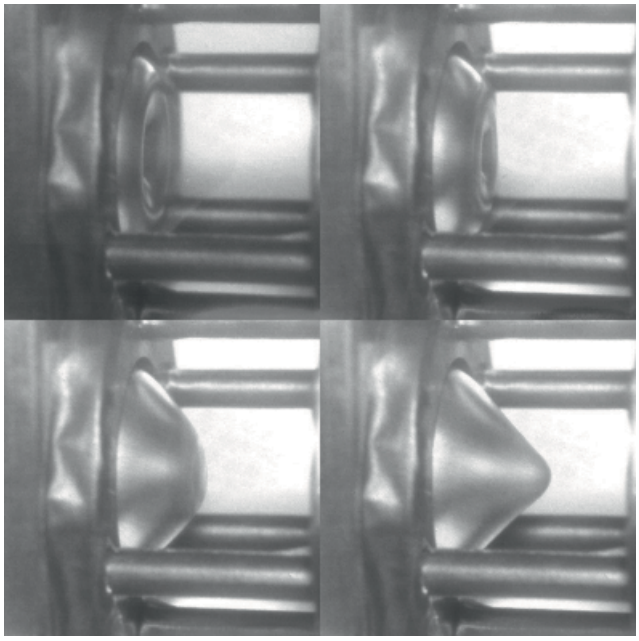
Institute of Forming Technology and Lightweight Construction, Technical University of Dortmund,
www.iul.uni-dortmund.de



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