hsfc pro
12bit ultra speed intensified imaging

- four MCP-image intensifier camera modules
- ultra fast shutter down to 3ns (optional 1.5ns) in single mode
- excellent sensitivity of the system allows single photon detection
- 12bit dynamic range
- ultra fast recording of up to 4 full frame resolution images with 1ns interframing time
- four high resolution CCD image sensors (1280 x 1024pixel)
- four PCI interface boards
- spectral sensitivity from VIS to NIR
- binning (horizontal & vertical)
- thermo-electrical cooling (Peltier) 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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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	%	@ 500nm typical	40
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 12.5MHz	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 of MCP	380..1300
exposure time	s		3ns..1000s (optional 1.5ns..1000s)
anti-blooming factor		@ 100ms 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 : 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

trigger, auxiliary signals			TTL level, light 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		500
photocathode material			S20, S25, GaAs, GaAsP, others on request
phosphor screen material			P43, P46
image intensifier pitch distance	µm		6
image intensifier MCP resolution (hor x ver) [5] type			single stage MCP
image intensifier diameter	mm		25
image intensifier system resolution	lp/mm	@5% MTF resolution (hor x ver) [6] typical	>60
shortest gating time	ns		3 (optional 1.5)

[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	proximity focused MCP (single stage MCP)-2nd generation
	optional	HighRes MCP (6µm channel)
	output window	glass
optical coupling	coupling between image intensifier and CCD: MCP to CCD via “ultra speed tandem lens” (collimator lens f2.5/100mm) and output lens (f1.0/33mm or f1.4/46mm) depending on CCD sensor size transmission efficiency > 20% vignetting < 3% resolution > 60 lp/mm, distortion free	
trigger modi	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, 10ns.. (in 5ns steps) ..30ns.. (in 10ns steps) ..100ns.. (in 20ns steps) ..1000s
	delay times:	0ns.. (in 1ns steps) ..50ns.. (in 5ns steps) ..100ns.. (in 20ns steps) ..1000s
	maximum pulsing frequency: 3kHz	

	highrate gating mode: exposure times: 20ns.. (in 20ns steps).. 1000s delay settings: 20ns.. (in 20ns steps).. 1000s maximum pulsing frequency: 2MHz
sensitivity	>100 counts / photo electron with P43 phosphor > 20 counts / photo electron with P46 phosphor
exposure modi	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 20ns.. (in 20ns steps) ..1s, each delay time 20ns..(in 20ns steps)..1s time between two images on same module depends on phosphor decay time, the minimum delay time is 500ns
CCD integration time	1ms – 1000s selectable for adjustment to phosphor decay integration. Starts automatically, triggered by gate unit
max. imaging freq.	for full resolution images: 4 images: 500 Mega fps (non-overlapping, 1.5 ns exposure time) 8 images: 8 Mega fps (non-overlapping, double exposure mode)
jitter	at exposure and delay times < 100ns: < 0.5 ns at exposure and delay times > 100ns: < 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 (better than Pentium II computer with 350 MHz or more).
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	1ms	4ms	100%
P46	0.2 – 0.4µs	2µs	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	830	23	$4 \cdot 10^{-14}$	30 000
GaAsP	500	50	$2 \cdot 10^{-14}$	10 000

(data courtesy of Hamamatsu Photonics)

spectral response of MCP

Spectral sensitivities of different MCP photocathode materials:
S25 (multialkali) > [-04] & [-08]
S20 (multialkali) > [-01] & [-05]
GaAs > [-61]
GaAsP > [-64]

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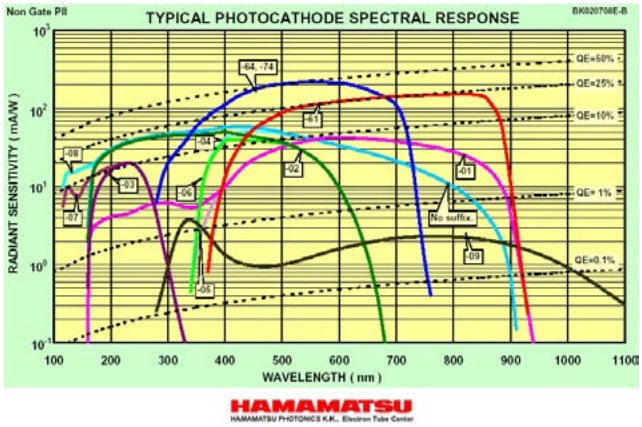
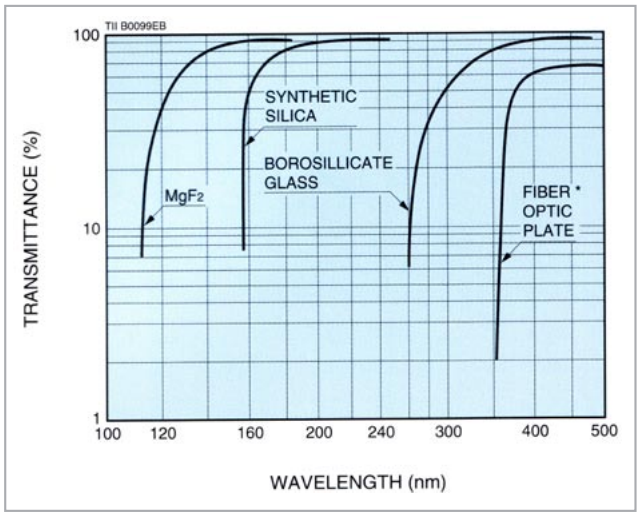
Hamamatsu Photonics,
Herrsching, Germany,
www.hamamatsu.de



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.

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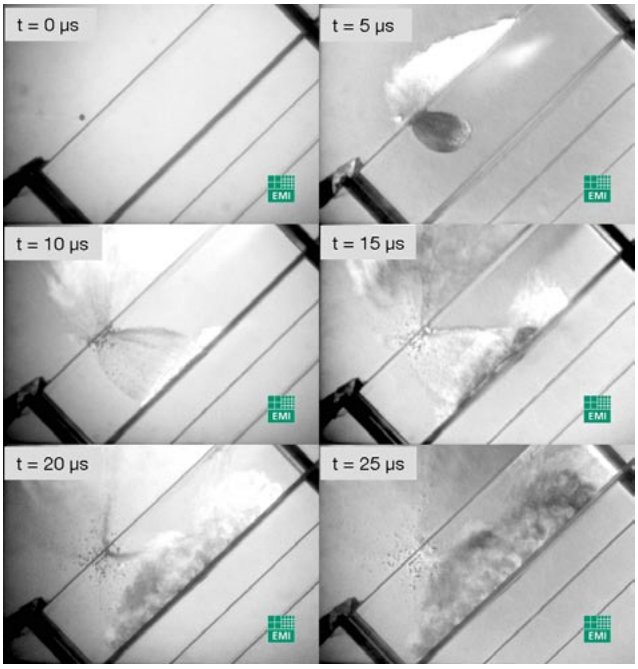

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