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Optical Bonding Technology

Wash-Out VS Bonded

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Display enhancement for added value

- Improved optical performance
- Allows sunlight readability
- Improved mechanical shock and vibration protection
- Hugely improved display value in harsh/uncontrolled environments

Why is it necessary?

- Modern TFT LCD's have vastly improved specifications.
- 'Industrial' type LCD's often offer even higher performance (for an increased cost).
- Brightness is regularly 300 – 400cd/m2
- Contrast 400:1+
- 'Transflective' types are available for improved sunlight readability

All have limitations – Bonding will still extend the performance

- Use of a Touchscreen, privacy filter, or any protective surface will still have extremely detrimental effect on display performance.
- Current off the shelf technologies cannot meet true ‘Sunlight Readable’ performance for outdoor applications
- Bonding is not an alternative to these advances, it ***extends*** the performance of the underlying display

Where is it useful?

- High Ambient lighting (Sunlight) conditions
- Any situation where a Touchscreen is used
- Any situation where a Protective cover is used
- If the display has to be IP or NEMA rated (for protection from water, dust, etc)
- If the LCD is vulnerable to mechanical shock or vibration
- Where the display is operating at the high end of it's market

Markets

GDS
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Outdoor

Military

Avionics

GPS

Marine

In vehicle computers

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Optical Improvements

How it works - Basic Principles 1

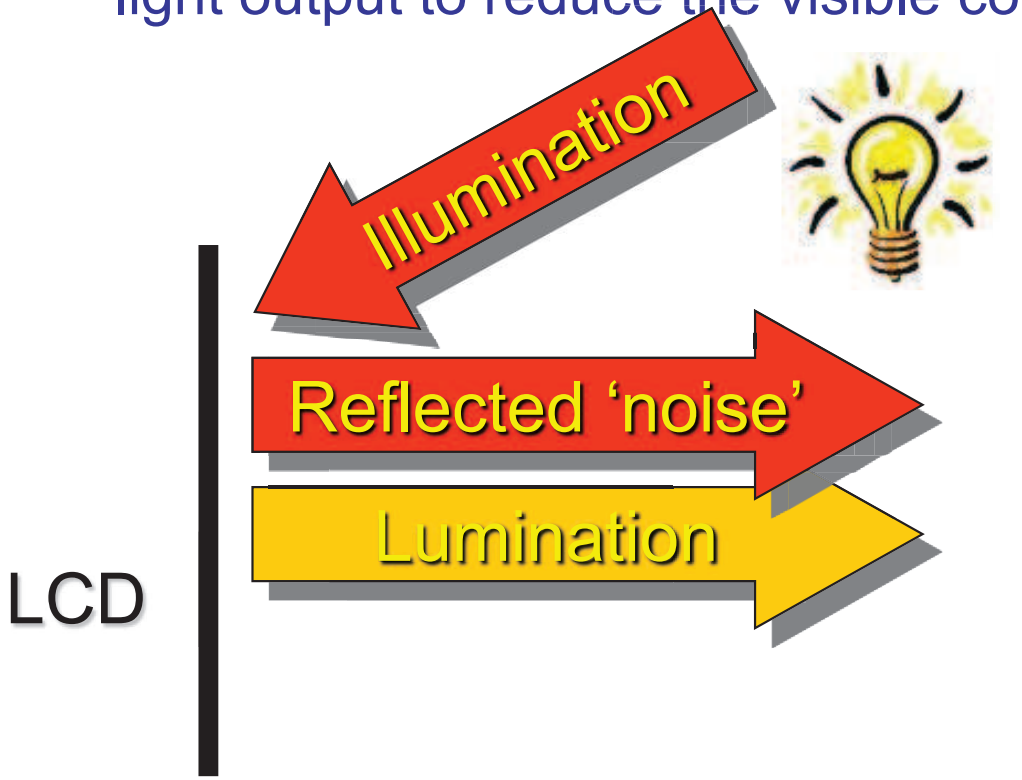
$$CR = \frac{L_{White}}{L_{Black}}$$

- CR = Contrast Ratio (typically >200:1)
- As referred to in LCD panel manufacturer spec sheets

- Really only applies to measurements taken in a dark room with no ambient lighting (reflections).
- Often does not take account of the angular distribution of light from an LCD panel

Real world situation – Lumination Vs Illumination

Surface reflections interfere with the displays modulated light output to reduce the visible contrast.



- Lumination depends on the panel brightness
- remember a 400cd/m2 panel is only that bright with a fully white screen
- Reflected noise can reach 1500cd/m2 in direct sunlight

Negative impact of reflections

- By raising the black level as well as the white the contrast ratio (W/B) will be reduced
- Less ‘dynamic range’ means less detail in images and text is harder to read.
- Addition of ‘white’ light de-saturates the colours making the image appear washed out
- Bright spots cause ‘glare’. The visual system cannot properly adjust to see the displayed image

Why is contrast so important?

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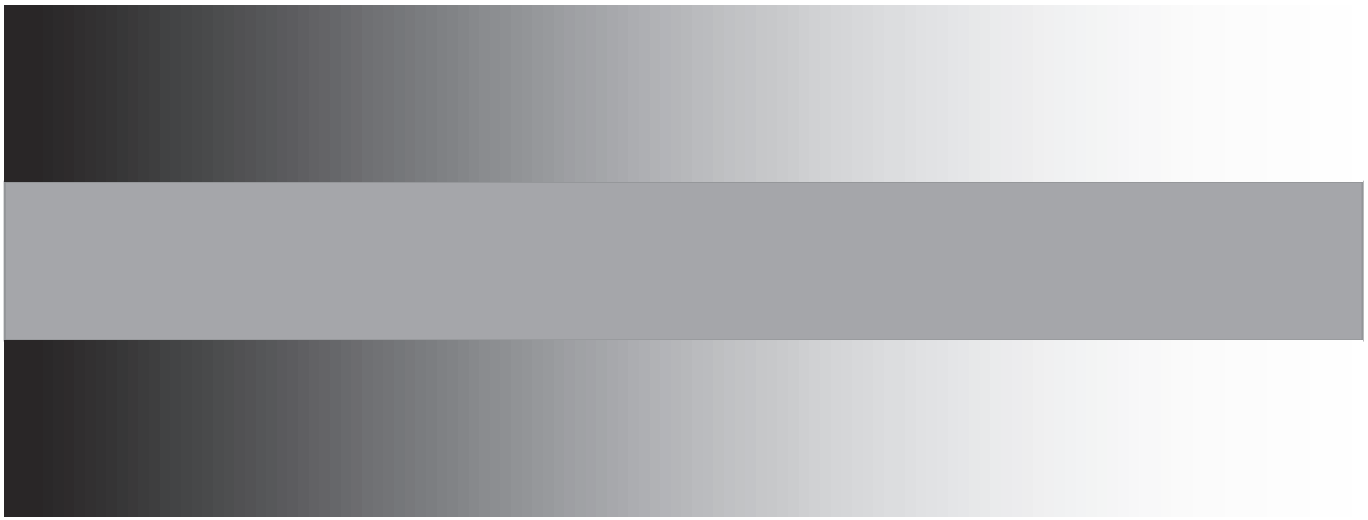
- Visual perception is a very complex process. A combination of physical detection and mental processing that feeds back to affect the physical detection.
- Example – Lateral Inhibition

A Monochrome bar **?**



Why is contrast so important 2

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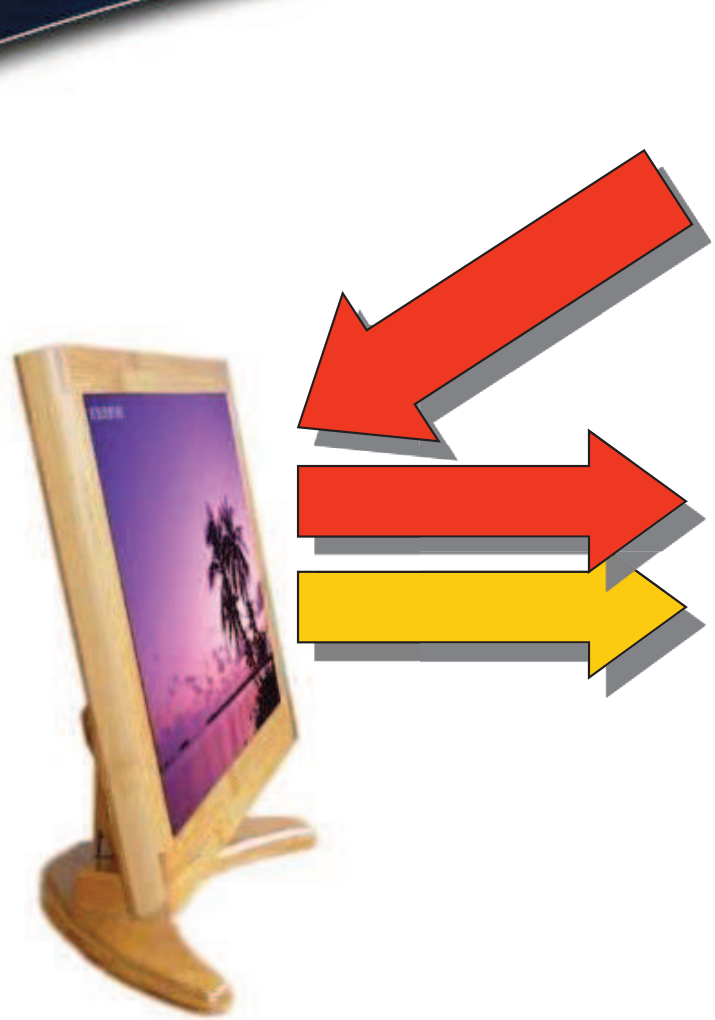
- Shows that the luminance or ‘brightness’ alone is not very useful information for interpreting an image
- The visual system tunes it out to focus on contrast between different elements in the image
- The visual system only ‘sees’ the difference between luminance levels
- Higher brightness displays usually offer a better looking picture in high ambient light because of improved visible contrast

High Brightness LCD panel



Darkroom

$$CR = \frac{L_{White}}{L_{Black}} = \frac{450}{1} = 450$$

+ Sunlight

$$CR = \frac{L_W}{L_B} = \frac{450+500}{1+500} = 1.9$$

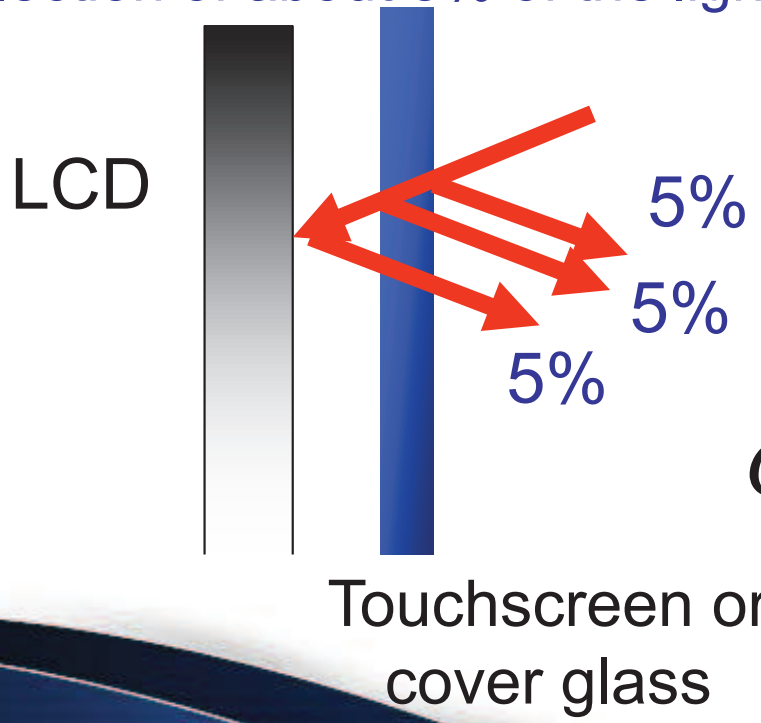
Reflection = 5% x 10,000cd/m2 incident light

What about if a front surface is required?

- A front glass will have a large negative impact on the visible contrast

Includes Touchscreens, Anti-vandal glass, Privacy filter, moisture protection etc.

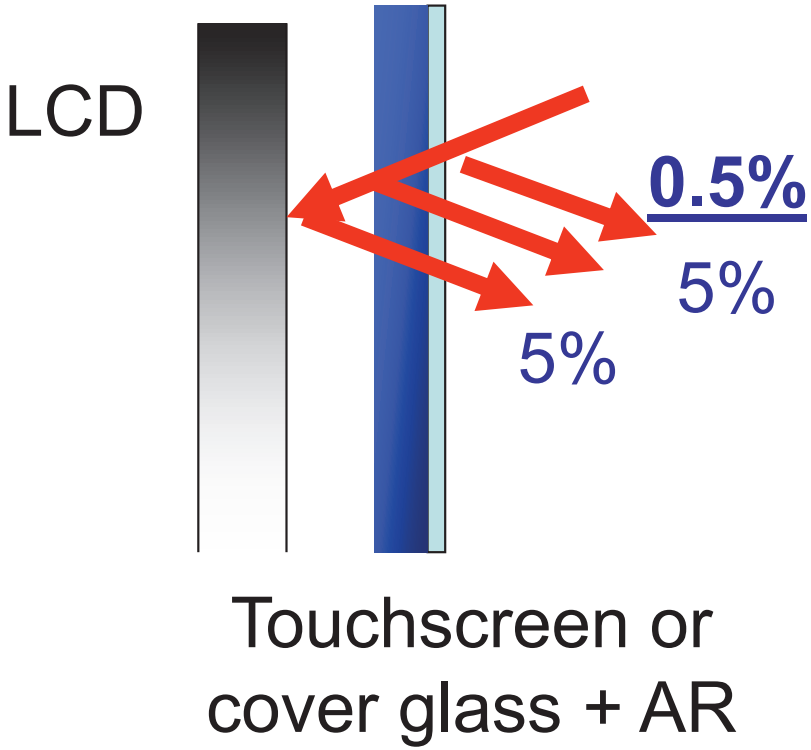
- Every interface (glass to air and air to glass) will lead to a reflection of about 5% of the light



Now virtually no contrast in direct sunlight

$$CR = \frac{L_w}{L_B} = \frac{450 + 3 \times 500}{1 + 3 \times 500} = 1.299$$

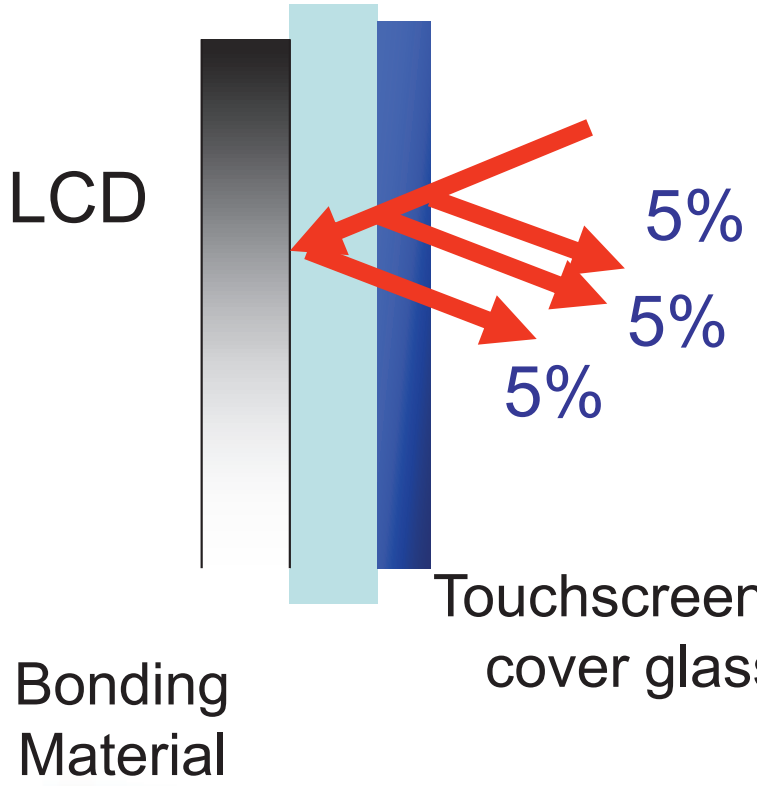
- AR coating will reduce the reflected energy to between 0.4 and 1%



- An improvement but still nowhere near the darkroom performance

$$CR = \frac{450 + 2 \times 500 + 50}{1 + 2 \times 500 + 50} = 1.408$$

An additional layer of ‘bonding material’ effectively removes two of the reflective surfaces

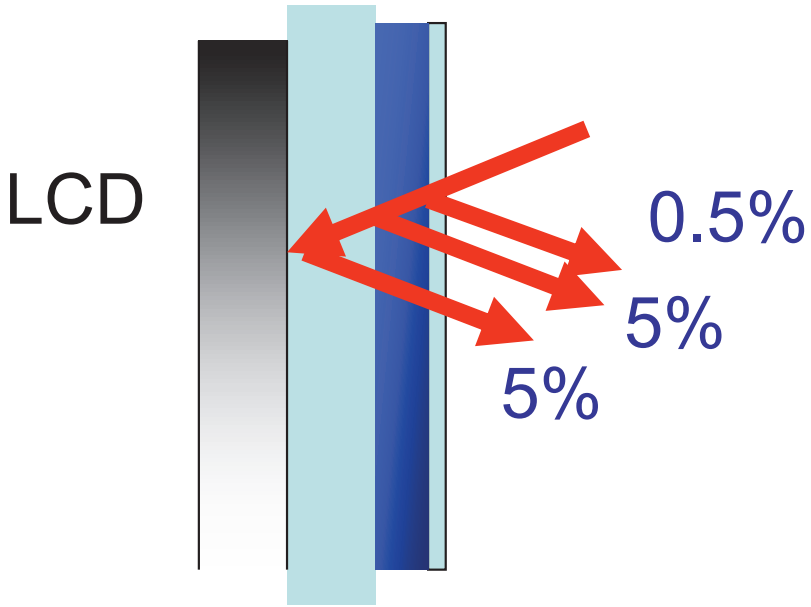


$$CR = \frac{L_W}{L_B} = \frac{450+500}{1+500} = 1.9$$

The same as before any front surface

Use AR coating and GDS-Bond together

Now that the two additional reflections are removed the AR coating becomes far more effective



$$CR = \frac{450+50}{1+50} = 9.8$$

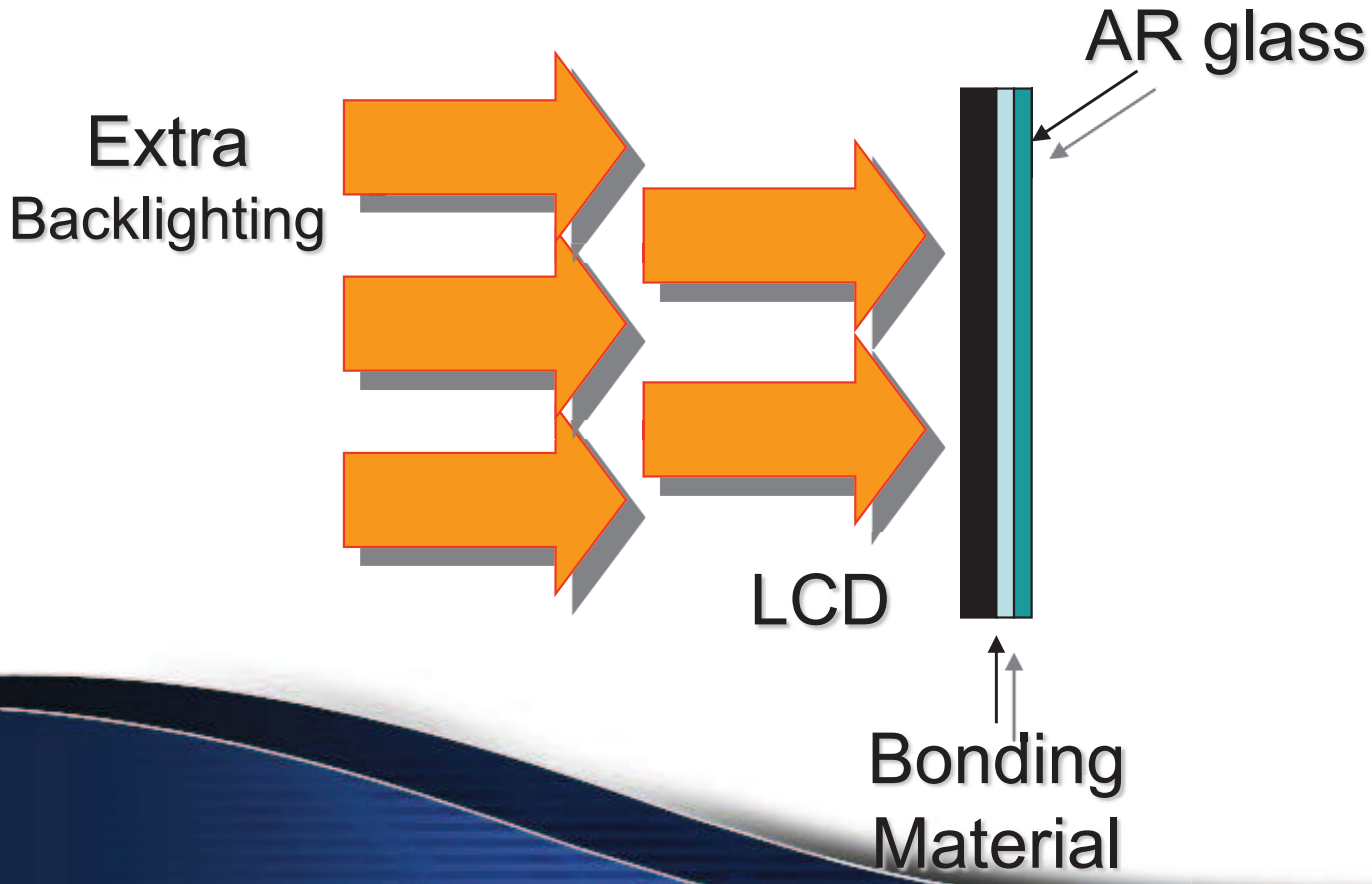
A real sunlight readable display

Sunlight Readability – Alternatives to bonding

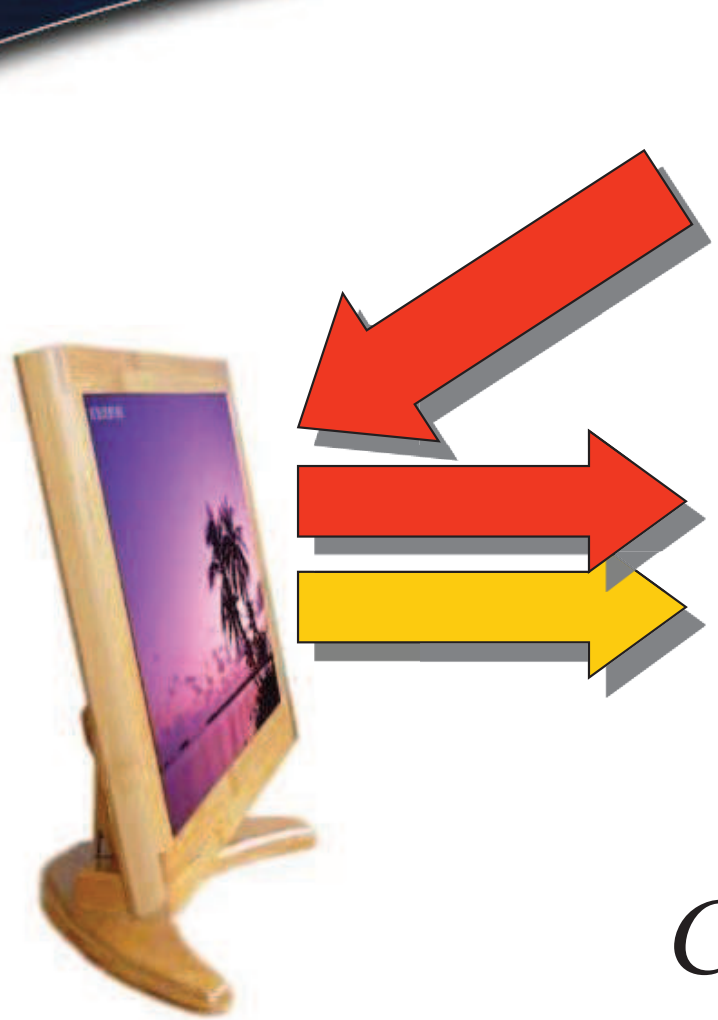
- ‘Active’ brightness enhancement
  - Causes Thermal issues (Clearing point of LCD panel)
  - Increased power consumption
  - Raises black level as well as White (inefficient)
- Simple AR coating (air gap or laminated)
  - Reduces surface reflections but does not give ‘sunlight readability’
  - Air gap can lead to greenhouse effect with solar loading (thermal issues)
  - Inefficient use of AR treatment

Best Solution ?

Best current solution is a combination of all three. Addition of more backlighting power and bonding of optically enhanced glass



High brightness alone will not reach sunlight readable performance



$$CR = \frac{L_W}{L_B} = \frac{1500}{4} = 375$$

+ Sunlight

$$CR = \frac{L_W}{L_B} = \frac{1500+1500}{1500+4} = 1.99$$

Ruggedization

Key mechanical / non-optical benefits of bonding

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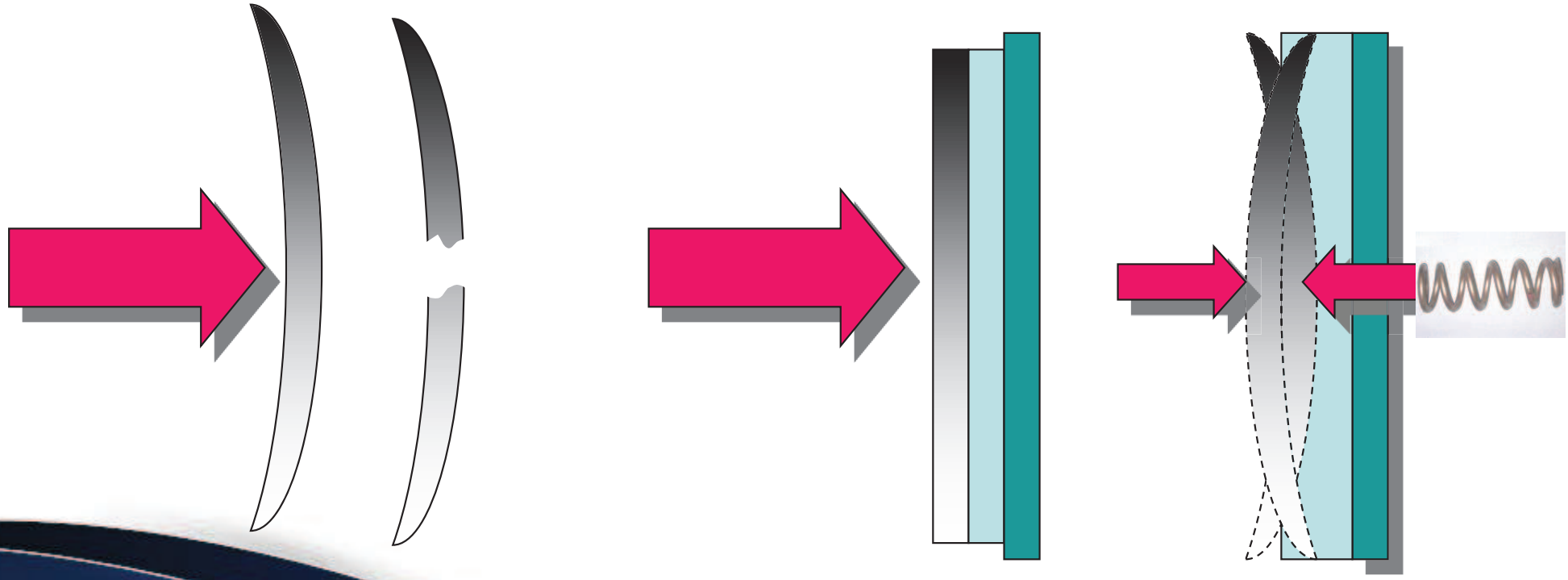
- Allows for fully sealed and mechanically toughened front surface with no optical degradation
- Increased resistance to shock and vibration for the fragile LCD glass component – due to bonding material itself.
- Removal of any risk of dust behind the front cover/touchscreen etc.
- Removal of screen front greenhouse effect
- Removal of the front screen condensation issue for sealed front covers
- Removal of parallax effect can enable new designs

Shock and vibration resistance

- Bonding material is jelly like, a perfect shock absorber
- Dampens any movement of the panel



Screen Contamination

- Dust and dirt
- Impair optical performance
- May require difficult cleaning operation even the removal of the touchscreen / front cover
- Screen front condensation during temperature changes