
# Film Grain Technology

## Hollywood Post Alliance
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**Jeff Cooper**
**jeff.cooper@thomson.net**

TECHNICOLOR. grass valley RCA THOMSON

# What is Film Grain?

- **Film grain results from the physical granularity of the photographic emulsion**
- **Film grain is most noticeable at high resolutions and on high quality displays**
- **Preservation of the grainy appearance of film is desirable for artistic reasons**
- **Film grain characteristics from different film stocks have a wide variety of size, shape, intensity, and color**

**In digital media, film grain management is a key tool.**

# Film Grain Encoding

## Definition of the problem

- **Film grain preservation is a challenge for video compression encoders:**
  - **Film grain has very high entropy and is not very compressible using block-based motion compensation prediction**
- **No specific strategies have been defined in previous standards to encode film grain**
  - **Solutions to code the film grain (removing coding thresholds, etc.) are extremely bit-rate costly**
  - **Attempting to encode film grain often results in coding artifacts**
- **The lack of film grain can create plastic looking images**

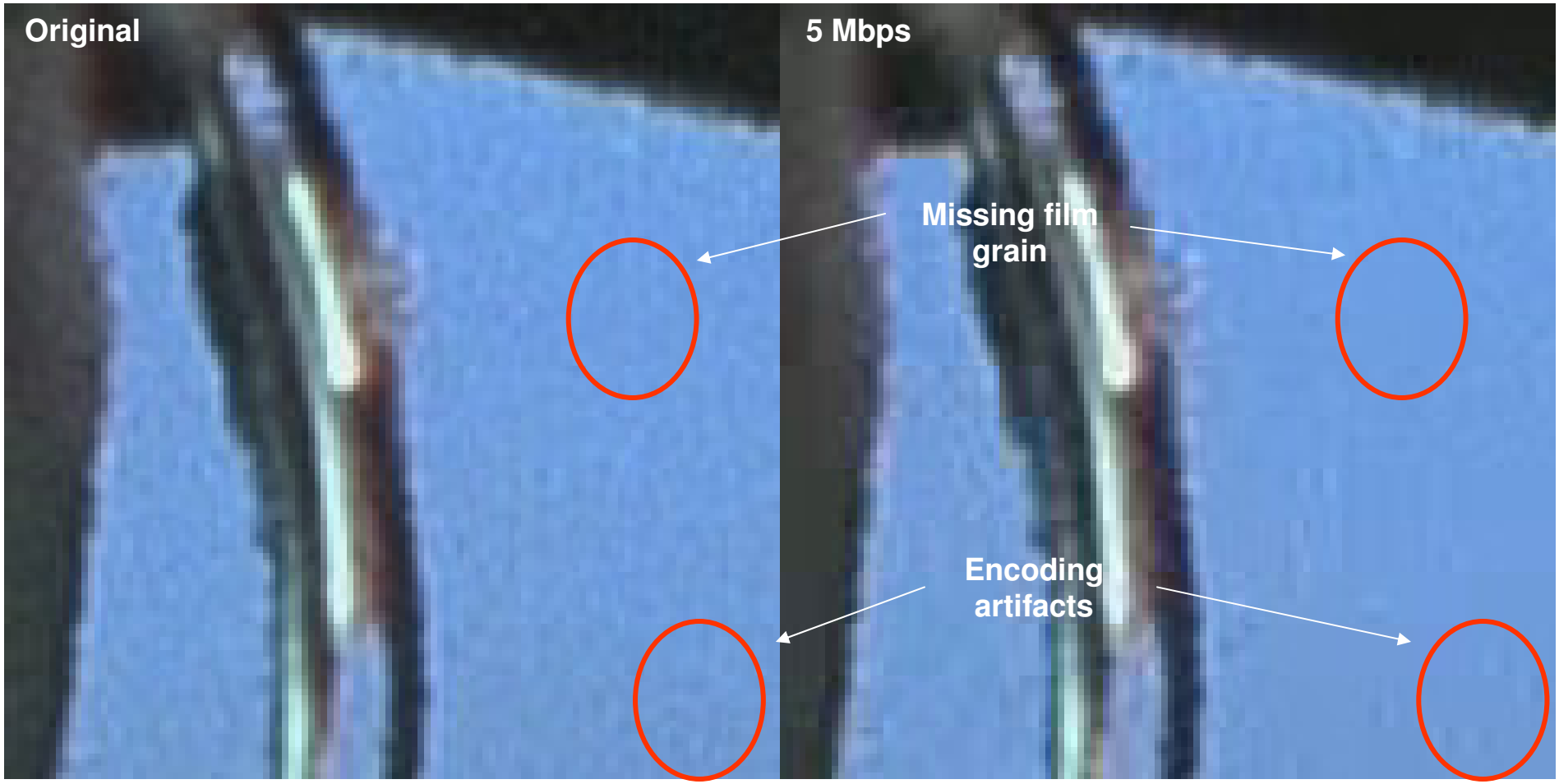
# Film Grain Encoding

## Definition of the problem

- **Video coding of film grain creates artifacts.**
- **Artifacts dependent on content and bit-rate:**
  - **Low - Medium bit-rate:**
    - **Mostly missing film grain.**
    - **Flat images.**
  - **Medium - High bit-rate:**
    - **Patchy, blocky grain.**
    - **Loss of grain especially in areas of motion.**

# Film Grain Encoding

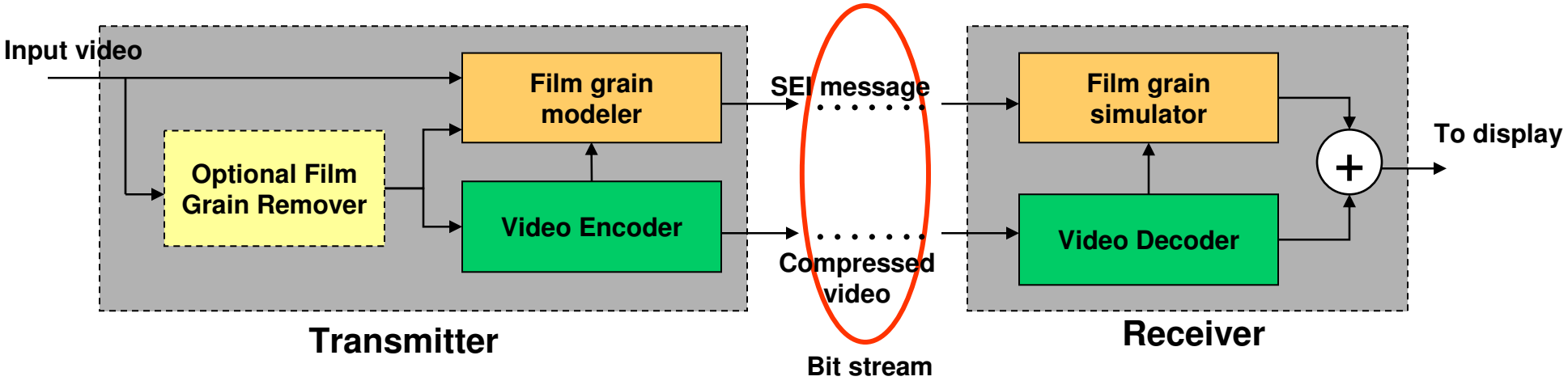
## Example of missing grain



# Film Grain Encoding

## Proposed solution

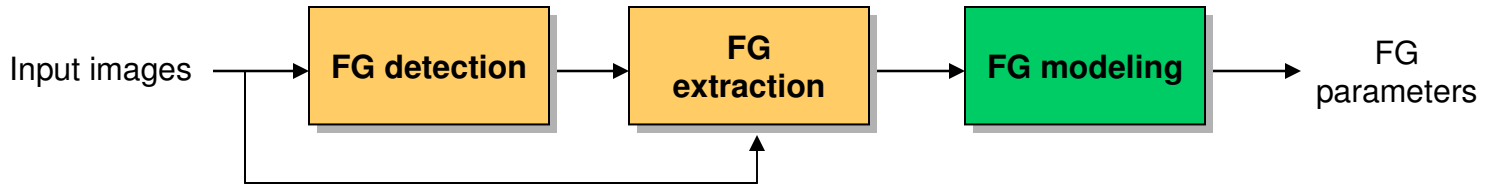
- **Transmitter:**
  - **Remove the film grain for more efficient encoding (optional & not specified)**
    - **Some film grain is lost just from encoding alone**
  - **Model the film grain and send characteristics in a film grain message**
- **Receiver:**
  - **Simulate film grain according to SEI parameters**
  - **Re-insert film grain to decoded images prior to display**



# Film Grain Modeling Process

## At Video Preparation Stage

- **Modeling Process:**
  - **FG detection:**
    - **Detect whether the input source comes from film**
    - **Detect suitable regions for extracting FG**
  - **FG extraction:**
    - **Use filters to remove/attenuate film grain from image, reducing encoder burden**
  - **FG modeling**
    - **Use model to determine film grain characteristics**



# Film Grain Extraction

- **Goal: remove/attenuate film grain from the original source.**
- **Technique: filters preserve the fine details while removing film grain.**
  - **Film grain is temporally uncorrelated which allows removal of film grain from image objects.**
- **Features: adapt filtering strength,**
  - **to content,**
  - **to target bit-rate,**
  - **in some cases, no filtering is required.**

# Film Grain Models

- There is extensive knowledge on film grain modeling and simulation
- Film grain models typically characterize:
  - Intensity – how apparent film grain is in the image
  - Size – size of film granularity
  - Color correlation – color attributes of film grain
- Thomson selected one model known to give high quality results:
  - Frequency filtering
    - Based on 2D band pass filtering in the frequency domain

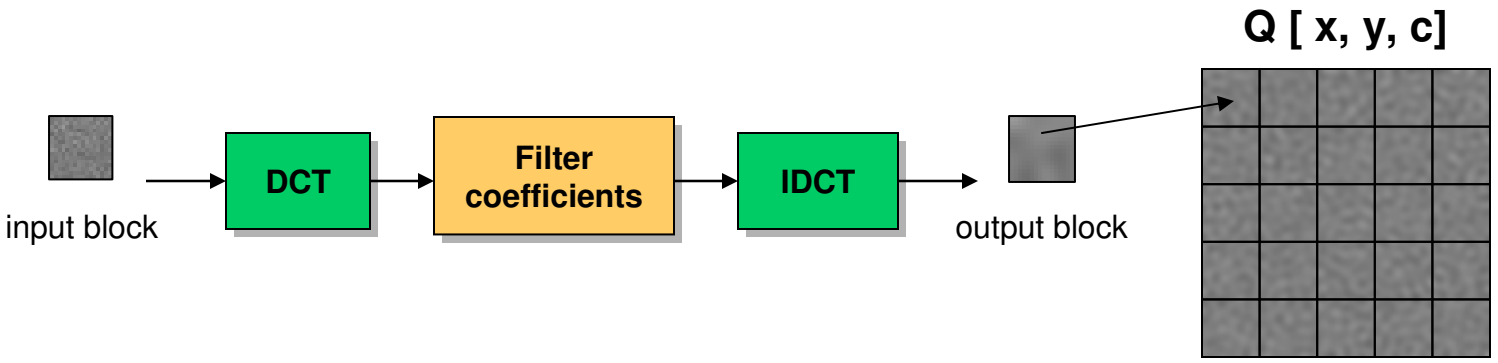
# Film Grain Modeling

## Frequency-filtering

$$G[x, y, c] = ( p * Q[x, y, c] + u * G[x, y, c-1] ) >> log2\_scale\_factor$$

where

- **Q[ x, y, c ]** is a two-dimensional random field, generated by filtering blocks of random values of normalized Gaussian distribution N(0,1),
- **p** is the noise standard deviation, and
- **u** is the cross-color correlation.



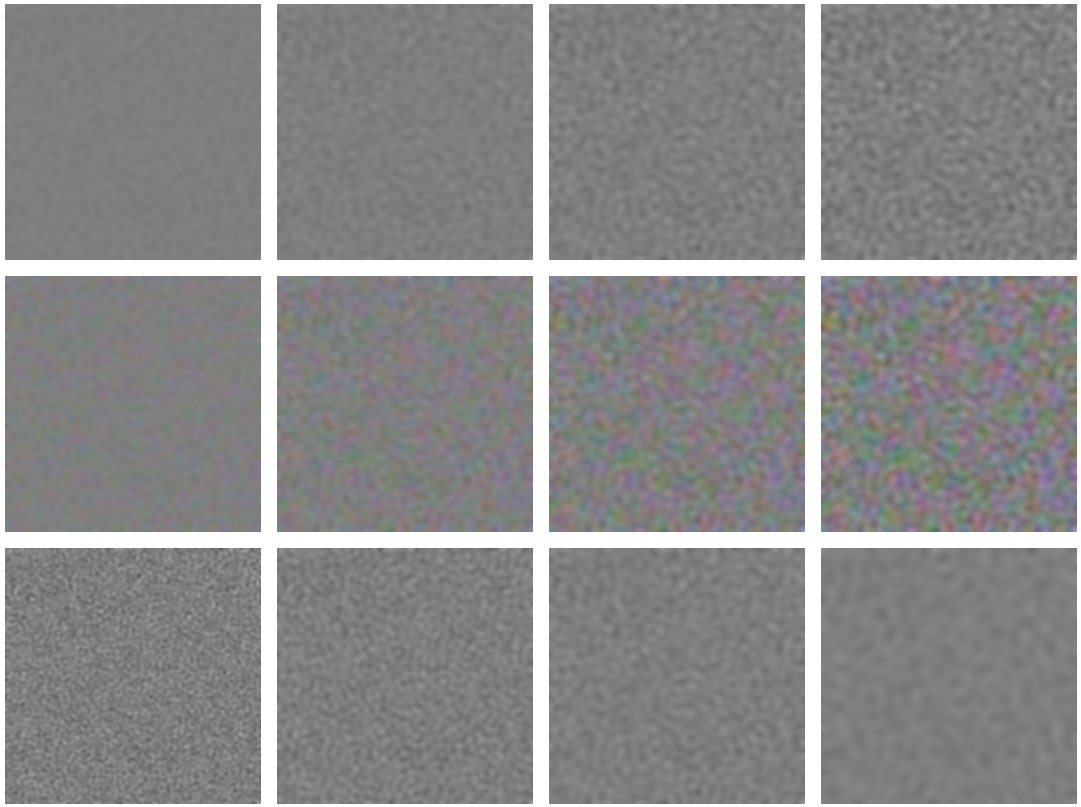
# Film Grain Modeling

## Frequency-filtering

variations in intensity →

variations in color and intensity →

variations in shape and size →



# H.264 Film Grain SEI Message

## Supplemental Enhancement Information

- The Film Grain SEI message format has been defined by JVT for MPEG-4 AVC (H.264).
- Conveys information required to simulate the original film grain, typically 60-70 bytes per GOP.
- SEI messages are optional and independent of profiles.
- The Film Grain SEI message applies to both Main Profile and FRExt decoders.

**SEI example**

```
0    # cancel flag : 0=FG, 1=no FG
0    # model : 0=DCT,  1=AR
0    # color description present flag
0    # blending mode : 0=add, 1=mult
5    # log2s
1    # compo                resent flag
0    # compo                resent flag
0    # compone       2 p            nt flag
6    # nb of  ntensi                ls minus 1
1    # nb o  param m
[0      50]      60
[51     60]     110    8
[61     80]     145    8
[81     100]    220    8
[101    150]    225    8
[151    180]    190    8
[181    255]    150    8
1    # film grain repetition period
```

luma intensity range

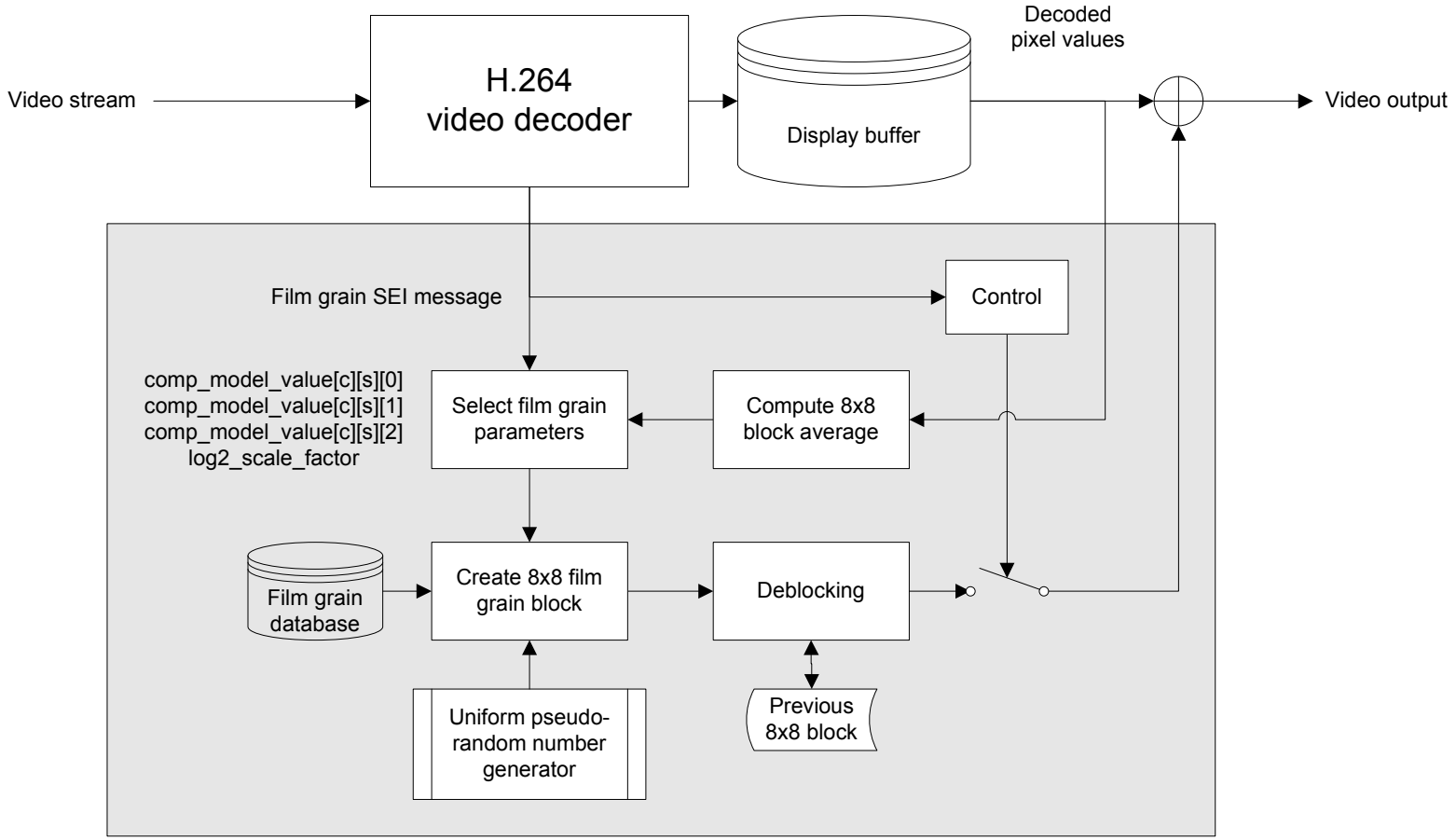
Film grain intensity

Film grain size

# SMPTE RDD-5 : FGT Decoder Specifications

- **Bit-accurate Film Grain Simulation**
  - **Bit-accurate film grain simulation is accomplished by specifying:**
    - **a database of film grain patterns;**
    - **a uniform pseudo-random number generator; and**
    - **a precise sequence of operations.**
  - **Film grain can be simulated independently for each color component**

# SMPTE RDD-5 : Film grain simulation process



# SMPTE RDD-5 : FGT Complexity Overview

- **FGT Low Complexity Decoder**
  - **Film Grain database approach**
    - **Avoids complexity of block based DCT/IDCT and associated memory interface design issues.**
  - **Database approach achieves minimal operations per pixel**
    - **FGM Spec requires 5.8 additions, 1.0 multiplies, and 2.5 shifts per pixel.**
    - **As comparison, this is 48 times less complex than a direct DCT approach.**
  - **Flexible Implementation**
    - **Designer has several trade off's in implementation.**
    - **HW Designs require 5K gates of digital logic, 40KB RAM**
    - **HW and SW designers can take advantage of SIMD friendly functions**
    - **PC Benchmark: FGT requires 5% additional CPU cycles over MMX/SSE optimized H.264 decoder**

# Status of Film Grain Technology

- **Film Grain Syntax Adopted by H.264 as an SEI message**
  - **JVT adopted FGT SEI for MPEG-4 AVC (H.264) specification in July 2004**
  - **Film Grain SEI is profile independent (FGT can be used with any H.264 profile)**
- **Film Grain Technology can be used with any video compression codec**
  - **Syntax (user data) can be supported by most compression codec standards**
- **FGT SMPTE RDD-5**
  - **SMPTE C24 Ballot passed in June 2005**
  - **FGT Decoder Specification Document RDD-5**

# Industry Support of Film Grain Technology

- **FGT Adopted by HD-DVD format (DVD-Forum)**
  - **FGT is mandatory for all HD-DVD players**
  - **FGT is optional for HD-DVD discs**
  - **Three different exhaustive subjective tests were performed including Hollywood "Golden Eyes" during the evaluation period**

- **Announced Silicon and Other Solutions**
  - **Broadcom BCM7411D : HD-DVD/Blu-Ray compatible H.264 decoder chip, including FGT**
    - http://www.broadcom.com/press/release.php?id=801423
  - **Thomson developing solutions for services and products**
  - **Numerous companies have licensed Thomson FGT software and conformance bit streams**

# Film Grain Technology Benefits

- **Reduction of bit rate and/or improvement of video picture quality**
  - **The amount of efficiency gain is dependent on content and bit rate targets**
  - **Drastic reduction in bit rate is possible in many cases**
    - **20-50% bit rate reductions at same subjective quality**

- **Transparent Video Quality Applications**
  - **Packaged media, post production, contribution networks, …**
  - **No film grain filtering typically needed**
  - **FGT enables reduction of bit rate while maintaining consistent film grain characterisitics**

- **Broadcast Applications**
  - **Film grain filtering can be done to reduce bit rate further by encoder**
  - **FGT enables very low bit rates, maintains consistent film grain**
  - **At low bit rates near the compression limit (compression artifacts), then FGT improves subjective picture quality**

# Film Grain Technology Demos

- **Demo 1: Video Quality**
  - **HD Content, Split Screen**
    - **1920x1080, 24 fps, YUV 4:2:0**
    - **High motion, weak film grain**
    - **AVC @ 4 Mbps and 8 Mbps**
    - **AVC @ 4 Mbps and 8 Mbps with FGT**

- **Demo 2: Post Production Tool Prototype**
  - **PC Prototype of a Film Grain Post Production Tool**
  - **Features include**
    - **PC application with GUI controls for SMPTE-RDD5 FGT parameters**
    - **Automatic detection algorithm for FGT parameters**
    - **Viewing window for real time adjustment subjective evaluation of FG parameters**

# Summary

- **Film Grain Technology**
  - Allows management of film grain characteristics in digital video systems
  - Improves video quality of film-based content in compression systems
  - Enables high quality HD video at lower bit-rates
  - Can be adjusted based on content and bit-rate targets
  - Low complexity for consumer devices
  - Suitable for a variety of applications
    - Packaged Media
    - Digital Post Production
    - Digital Broadcast

- **FGT Availability**
  - Specification available now (via SMPTE or Thomson)
  - Decoder software model available
  - Conformance bit streams and technical support available for implementers