Make the most of your visual simulation data: The TIB AV-Portal enables citation of simulation results and increases their visibility

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***Abstract*—There still exists no common standard on how to publish and cite visualisations of simulation data. We introduce the TIB AV-Portal as a sustainable infrastructure for audio-visual data using a combination of digital object identifiers (DOI) and media fragment identifiers (MFID) to cite these data in accordance with scientific standards. The benefits and opportunities of enhancing publications with visual data are illustrated by showing a use case from opto-electronics.**

I. Introduction

While visualisations of simulation results are quite common nowadays, there still exists no common standard on how to handle these visual data. In most cases the visualisations are kept on the private hard drive of the researcher who publishes only snapshots of the visualisations as figures in scientific articles. However, a growing number of scientists also publishes the visualisations as supplemental videos accompanying the respective article. This allows the reader to get more information on how the research results were found and how to interpret the data. Nonetheless, the way supplemental videos are published is in many aspects far from ideal.

Most publishers do not have the suitable infrastructure for hosting research data, software or scientific videos. Therefore, supplemental videos are often hosted on private webpages, platforms like youtube or only available on request. These solutions are neither sustainable, nor are the videos easily findable or citable. Furthermore, from a readers perspective it is often unclear if and how videos may be reused as no legal licence is associated with the video. Finally, even if all the before said is fulfilled, it is in general not possible to cite just part of a video, e.g. that single segment corresponding to a snapshot shown in the articles figure.

We illustrate the benefits of publishing visualisations of simulations in the AV-Portal (https://av.tib.eu) by comparing the current version of [1] with an enhanced version using the AV-Portal as an underlying infrastructure for the visual simulation data used in [1].

II. The TIB AV-Portal

The AV-Portal is a web-based platform for quality-tested scientific videos from the realms of science and technology.

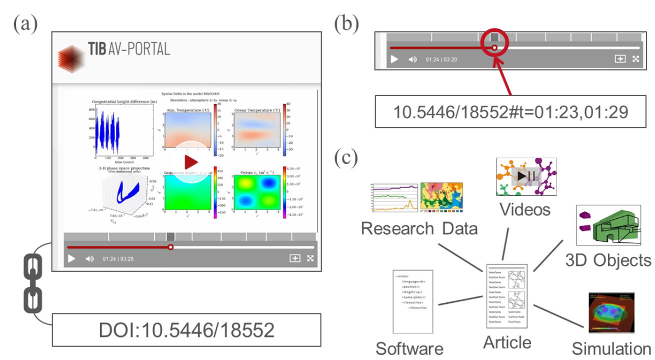

Fig. 1. Visual simiulation data as a scientific resource. (a) Videos in the AV-Portal are assigned a DOI. (Screenshot from [2]). (b) Video segments can be cited to the second using MFID. (c) Enhanced publications consist of the article and other accompanying materials such as data, software or videos.

It is developed in the Competence Centre for Non-Textual Materials at the German National Library of Science and Technology (TIB) in cooperation with the Hasso Plattner Institute for Software Systems Engineering. Automated video analysis, such as speech, text and scene recognition, allow for an easy search within the video content. Moreover, all videos in the AV-Portal are assigned a digital object identifier (DOI) that enables the users to cite and link to the article in accordance with scientific standards (cf. Fig. 1a). The combination of DOIs with a media fragment identifier (MFID) even allows to cite video segments to the second (cf. Fig. 1b).

Interlinking between article and video (and if applicable further supplemental resources) via DOI ensures a persistent connection between the different parts of a publication. This guarantees that the whole publication, i.e. the article and all related material, remains connected even if URLs are changed or similar (cf. Fig.1c). This procedure has already been well established in a collaboration between TIB and Copernicus Publications. In this collaboration the AV-Portal serves as a stable and sustainable repository for all supplemental videos and video abstracts published alongside any article in a Copernicus Journal. [3]

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III. Enhancing publications on device simulation

We consider a use case from opto-electronics and show how the presentation of results from [1] may benefit from enhancing the publication with the respective video of visualized simulation data. We compare the publication without those enhancements with an enhanced publication using the features offered by the AV-Portal. Finally we propose extensions of the current features to harmonize the citation scheme with the actual physical simulation parameters.

A. An example from opto-electronics

In [1] the current injection into single quantum dots embedded in vertical pn-diodes featuring oxide apertures has been studied using three-dimensional simulations of the carrier transport. The simulations revealed that the experimentally observed parasitic excitation of QDs located up to several micrometers away form the aperture can be explained by a rapid lateral spreading of the carriers after passing the oxide aperture, see Fig. 2a. Guided by these findings an improved device design has been proposed [1] which effectively suppresses the unintended current spreading and allows for an efficient electrical pumping of sub-micron sized regions, see Fig. 2b.

For the analysis in continuous wave (CW) operation mode (controlled by a bias voltage U) color-coded two-dimensional maps of the spatial distribution of the carrier density and the carrier flow for *one* specifically selected value of the bias voltage have been shown suitable for supporting the scientific argumentation. Here, a video showing the evolution of the carrier density together with the current flow for the a suitable bias sweep would be beneficial for the reader to gain insights in the mechanisms behind the observed phenomena.

For the pulsed operation mode the *temporal evolution* of the electron density in the active zone along a *line scan* (1D) across the two-dimensional density map has been shown, see Fig. 2, for demonstrating the excellent current funneling for the improved device design. Here, the interpretation of this plots would considerably benefit from a visualization of spatio-temporal evolution of the full two-dimensional carrier density.

B. Use of TIB AV-Portal to enhance publicatons

All videos published in the AV-Portal are assigned a persistent identifier, a DOI, which makes sure that a durable linkage between article and video is established. It allows the video to be cited according to scientific standards and asures the coherence of the whole publication (consisting of the article, videos, research data, etc.). Moreover, adding a media fragment identifier (MFID) to the DOI allows to cite single video segments down to the second. The MFID is written as ”#t=aa:bb,xx:yy”, where aa:bb and xx:yy are the start and end time of the video segment, respectively, given in units [minutes]:[seconds] (cf. Fig.1b). The combination of DOI and MFID therefore enables to precisely cite the parts of the video in which the physically relevant and interesting changes happen. Thus, the author is no longer forced to reduce the visualizations to snapshots.

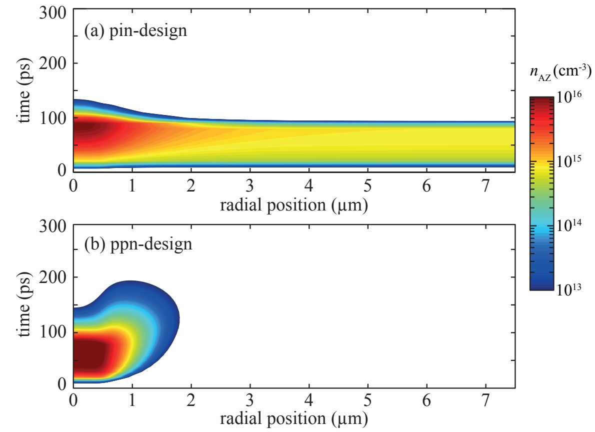

Fig. 2. Response of the electron density along the active zone in vertical p-n diodes with laterally oxidized apertures to a periodically pulsed contact voltage (100 ps long bias pules with repetition rate of 1 GHz on top of a constant bias voltage U_0 with 20 ps rise and fall time), see [1]. (a) pin-design, (b) ppn-design. Time is measured relative to the onset of the respective bias pulse. White areas indicate very small electron densities lower than 10^{13} cm^{-3}. The lateral carrier spreading observed for the pin-design is effectively suppressed for the ppn-design.

In our use case, e.g. one could guide the reader precisely to the frame in a video showing evolution of density distribution for the full bias sweep, which exactly corresponds to the depicted choice of bias voltage used for the snapshot by using a conventional citation in combination with the MFID. The introduction of domain-specific extensions (Refer frames by parameters, e.g. applied voltage, or physical simulation time, e.g. ps in our case) the could be a useful next step for authors interested in enhancing their publications by visualizations.

IV. Conclusion

To make the most of simulation data and other research output, those resources should be published alongside the classical article. Enhanced publications consist of a combination of the text describing the research and its results as well as underlying material such as research data, software or visualizations of simulations. Using the TIB AV-Portal as a platform for supplemental videos ensures a persistent linkage between article and video via DOIs and allows for citation to the second via a combination of DOI and MFID. Thus, simulations which depend on the evolution of a physical parameter (like the bias voltage U in Fig. 2) can be visualized using video and precisely cited. Thereby the natural restrictions of snapshots and figures can be resolved.

References

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